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Incorporating uncertainty into estimates of Atlantic Cod (*Gadus morhua*), Capelin (*Mallotus villosus*) and Arctic Cod (*Boreogadus saida*) consumption by Harp seals (*Pagophilus groenlandicus*) in NAFO Divisions 2J3KL

Tenir compte de l'incertitude dans l'estimation de la consommation de morue franche (*Gadus morhua*), de capelan (*Mallotus villosus*) et de morue polaire (*Boreogadus saida*) par le phoque du Groenland (*Pagophilus groenlandicus*) dans les divisions 2J3KL de l'OPANO

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Abstract

Consumption of prey by harp seals in NAFO divisions 2J3KL was estimated by synthesizing and integrating information on individual energy requirements, population size, distribution, and diet composition. Diets were estimated using reconstructed stomach contents collected between 1982 and 1998, inclusive. Uncertainty in the estimates of numbers at age, diets, residency in 2J3KL and the proportion of seals in nearshore areas, was incorporated into the consumption estimates. Based on their average diet, harp seals consumed an estimated 893,000 (95% CI: 682,000-1,100,000) tonnes of capelin, 186,000 (95% CI: 58,000-457,000) tonnes of Arctic cod and 37,000 (95% CI: 14,000-62,000) tonnes of Atlantic cod in 2000. The proportion of cod in nearshore diets varied among years and seasons with a significant increase in cod present in the winter 1998 diet. Generally low levels of cod were present in offshore winter diets while no cod were present in the Summer. Examination of the proportion of nearshore seal stomachs containing cod (prevalence), mean weights of Atlantic cod, Arctic cod and capelin in the stomach, and mean lengths of cod consumed indicated that during the winter of 1998, the prevalence of Atlantic cod in harp seals was higher than average but not the highest documented. However, the mean weight of cod in stomachs and the length of cod consumed were greater than previously seen. Improvements in estimates of consumption can be achieved by further diet sampling in offshore areas and increased information on residency of seals of all ages in the area. However, estimates will likely remain highly variable owing to the strong temporal and spatial variation observed in diet composition.

Résumé

La consommation de proies par le phoque du Groenland dans les divisions 2J3KL de l'OPANO a été estimée en synthétisant et en intégrant des données sur les besoins énergétiques individuels, la taille et la répartition de la population, ainsi que la composition des régimes alimentaires. Les régimes alimentaires ont été estimés à partir de contenus stomacaux reconstitués échantillonnés de 1982 à 1998. L'incertitude liée aux estimations de l'abondance par âge, des régimes alimentaires, du séjour dans les divisions 2J3KL et de la proportion des phoques se trouvant en zone côtière a été intégrée aux estimations de la consommation. D'après leur régime alimentaire moyen, on estime que les phoques du Groenland ont consommé 893 000 (IC à 95 % = 682 000-1 100 000) tonnes de capelan, 186 000 (IC à 95 % = 58 000-457 000) tonnes de morue polaire et 37 000 (IC à 95 % = 14 000-62 000) tonnes de morue franche en 2000. La proportion de morues dans le régime alimentaire des phoques en zone côtière variait selon l'année et la saison et a présenté une hausse significative à l'hiver de 1998. En général, les phoques en haute mer consommaient peu de morue en hiver et aucune l'été. La proportion des estomacs de phoques des zones côtières qui contenaient de la morue (prévalence), les poids moyens des morues franches et polaires et des capelans trouvés dans chaque estomac, ainsi que les longueurs moyennes des morues consommées indiquaient qu'à l'hiver 1998, la prévalence de morues franches dans l'estomac des phoques du Groenland était plus élevée que la moyenne, sans être la plus haute valeur jamais enregistrée. Par contre, le poids moyen et la longueur des morues trouvées dans les estomacs étaient plus élevés qu'auparavant. Il est possible d'améliorer les estimations de la consommation en échantillonnant davantage d'estomacs de phoques en haute mer et en obtenant plus de données sur le séjour de phoques de tous âges en haute mer. Toutefois, ces estimations resteront très variables en raison des fortes variations temporelles et spatiales de la composition du régime alimentaire.

Introduction

The failure in the Canadian East Coast Atlantic cod fishery has been attributed to a combination of excess harvesting, uncertain biological assessments, and ineffective fisheries management (FRCC 1999). Although fishery closures were enacted in the early 1990s, few stocks have shown signs of significant recovery (FRCC 1999). In particular, the 'Northern Cod' (*Gadus morhua*) stock which occurs off the east coast of Newfoundland along the southern Labrador shelf and northern Grand Banks (NAFO Divisions 2J3KL, Fig. 1) has remained at extremely low levels (DFO 2001). The reason for this lack of recovery is not clear but one source of concern is the potential impact of predation by seals.

The most abundant seal in the Northwest Atlantic is the harp seal (*Pagophilus groenlandicus*). Over the last two decades, this population has increased from less than 2 million in the early 1970s to over 5 million in 1996. Since then the population has remained relatively stable with an estimated total population of 5.2 million (95% C.I. 4.0 - 6.4 million) in 2000 (Healey and Stenson 2000). One obvious impact of these changes in abundance over the past 30 years is an increase in prey consumption.

The first step in determining the impact of predation is to obtain accurate estimates of consumption with realistic estimates of uncertainty. Prey consumption can be estimated using a bioenergetics model that incorporates information on population size, energetic requirements, diet composition and energy density of the prey, as well as the seasonal distribution of feeding (Harwood and Croxall 1988; Harwood 1992; Hammill and Stenson 2000). Using such a model, harp seals consumed an estimated 88,000 t of Atlantic cod off the Labrador and east coast of Newfoundland in 1994 (Stenson *et al.* 1997). Since then, this estimate has been revised as new data became available. Most recently, Hammill and Stenson (2000) estimated cod consumption by harp seals in NAFO Divisions 2J3KL at approximately 49,000 tonnes in 1996.

Modeling consumption by seals requires a wide range of information, much of which is poorly known. In the past, the large degree of uncertainty usually associated with consumption estimates has not been considered when the impact of fish consumption is discussed. Attempts to include uncertainty in estimates of consumption (e.g. Stenson *et al.* 1997; Shelton *et al.*1997) have been preliminary in nature and emphasized the need for a quantitative method for incorporating uncertainty into consumption estimates.

In this study, previous estimates of prey consumption by harp seals in NAFO Divisions 2J3KL were updated by incorporating recent diet data. Also, we use resampling techniques to quantify the uncertainty associated with these estimates by incorporating uncertainties associated with the estimates of diet, seasonal distributions, and population size.

Methods

Population Size

Estimates of population size were obtained from Healey and Stenson (2000), assuming mortality of seals during their first year was three times the mortality rate of seals one year of age and older (i.e. gamma = 3). Uncertainty (mean and standard deviation in the numbers in each age group (0 through 11 and12+) for each year was estimated from the population trajectories provided by Healey and Stenson (2000).

Seasonal Distribution

Harp seals are highly migratory and our knowledge of their seasonal distribution is primarily based on historical catch data, tag returns and, more recently, satellite telemetry (Table 1; Stenson and Sjare 1997). Northwest Atlantic harp seals summer on feeding grounds in the Canadian Arctic and/or West Greenland. During the fall and early winter, seals move southward along the Labrador coast. One component of this population remains off the east coast of Newfoundland/southern Labrador (i.e. 2J3KL, Fig. 1) while the other moves into the Gulf of St. Lawrence for whelping. In the spring, the animals return to their feeding grounds. Annual changes in ice conditions or food availability likely affect the seasonal movements of the population (Sergeant 1991). We assumed that the proportion of the annual energy requirements obtained from different areas is proportional to the residency of the animals in the area.

Following Hammill and Stenson (2000), 20% of all age groups were assumed to remain in the Arctic throughout the year while one-third of the adult population and 20% of young (ages 0-4) were assumed to enter the Gulf of St. Lawrence on December 1 and remain there until May 30. The remainder of the population is assumed to be present in the waters off Newfoundland. A small proportion (5%) of the seals that migrated southward was assumed to remain in the study area for the entire year, with the proportion in Newfoundland and Gulf waters remaining the same as for the winter period. The residency period of seals in southern areas (i.e. NAFO Divisions 2J3KL and southward) was taken from Stenson and Sjare (1997). On average, seals entered this area November 21 (sd=8.1 days) and remained until July 6 (sd=6.7 days).

We assumed that the proportions of energy obtained by harp seals in the offshore and nearshore areas in NAFO Divisions 2J3KL had not changed from those in Hammill and Stenson (2000); 90% and 87% of the energy required in summer and winter periods, respectively, were obtained in offshore areas (Table 1). These estimates were derived by plotting the locations of seals in Divisions 2J3KL obtained from satellite telemetry (Fig. 2; Stenson and Sjare 1997). Based upon discussions with sealers who obtained the samples, we assumed that the nearshore area was represented by a band 25 km from the coast. To test the significance of this assumption a band of 50 km was also identified. Increasing the width of the nearshore band to 50 km did not significantly decrease the proportion of seals in the offshore region (Table 1). Variability in the proportion of seals that occurred in offshore areas was modeled using the Beta general and exponential distributions for the Summer and winter periods, respectively. These distributions were chosen using the distribution function of @Risk (Palisade Corporation, Newfield NY, USA 2000).

Energy Requirements

Energy requirements were assumed to be constant throughout the year. Individual energy requirements were calculated using:

$$GEI_i = GP_i * (AF * 293 * BM_i^{0.75}) / ME_i$$

Where GEI is daily gross energy intake (kjoules/d) at age i, and GP is the additional energy required by young seals. GP was set at 1.8, 1.6, 1.4, 1.3, 1.1, 1.1, and 1.0 for animals aged 0, 1, 2, 3, 4, 5, and ≥6 yrs respectively (Olesiuk 1993). The activity factor (AF) was assumed to be 2 (Worthy 1990), to approximate the average daily energy requirements as a multiple of the basal metabolic rate ($293*BM_i^{0.75}$; Kleiber 1975), where BM is body mass in kg. The metabolizable energy (ME_i) was set at 0.83 (Ronald *et al.* 1984), assuming that seals consume primarily fish. Growth in body mass (BM) at age i was described using a form of the Gompertz growth curve (Hammill and Stenson 2000).

Diet

The diet of harp seals was estimated using reconstructed wet weights of stomach contents (Lawson *et al.* 1995). Prey lengths and weights were estimated from hard parts using part length – total length and part length – and/or length – weight regression equations. If prey were intact direct weights were recorded. If hard parts were too digested or eroded to accurately measure, an average value was calculated for that prey species in the same year, season and location. Regression equations were obtained from published sources (Härkönen 1986; Benoit and Bowen 1990; Lidster *et al.* 1994; Lawson *et al.* 1995; Proust 1996) when available. Healey and Lilly (unpublished) provided the otolith – total length regression used for Atlantic cod:

$$FL = 4.4986 + 0.1184 * OL + 0.1997 * OL^2$$

where FL is fork length (in cm) and OL is otolith length (in mm). The cod length-weight regression equation:

$$FM = 10^{(-5.2106 + 3.0879 * LOG_{10}(FL))} * 1000$$

where FM is fish mass (in gm) and FL is fork length (in cm), was taken from Lilly *et al.* (1998).

Reconstructed wet weights were converted to energy densities using published energy values for each prey species (Tyler 1973; Griffiths 1977; Montevecchi and Piatt 1984; Steimle and Terranova 1985; Lawson *et al.* 1998a). Samples were assigned to either a winter (October – March) or Summer (April – September) season and divided into geographical areas based upon designated NAFO areas and distance from shore.

To estimate uncertainty associated with diets, samples were grouped according to location and season of collection and simulated data sets of total energy consumed were created using a bootstrapping (i.e. resampling-with-replacement) technique (Resampling Stats, Arlington VA, USA 1999). Each stomach was treated as a unit for resampling purposes. This process was repeated 1000 times to generate estimates of total mass and hence energy, from which

proportions contributed by each prey group could be calculated. Visual examination of these distributions suggested that they followed a normal distribution and therefore, means and standard errors were calculated. To examine interannual variability in the diet, samples were grouped within calendar year and the proportion (mean and standard error) of Atlantic cod, capelin and Arctic cod in the diet was estimated.

Estimating Consumption and Uncertainty

The amounts of Atlantic cod, Capelin and Arctic cod consumed by harp seals in NAFO Division 2J3KL from 1965 – 2000 were estimated by modeling changes in population size, energy requirements, diet composition and seasonal changes in distribution. Uncertainty in these calculations was estimated by resampling (@Risk, Palisade Corporation, Newfield NY, USA 2000) the numbers at age, proportion of prey in the diet, residency period in southern waters and proportion of energy obtained from nearshore/offshore areas from distributions of these variables.

Results

A total of 4,453 prey-containing stomachs were collected in 1982 and 1986 -1998 from NAFO Divisions 2J3KL (Table 2). The vast majority of samples (93.8%) were obtained from the nearshore area. NAFO Division 3K accounted for 68% of the total samples. More samples were obtained during the winter period (n=3,270) due to the seasonal migration of seals out of the area during the summer (n=1,183).

Mean percent energy contribution of prey groups to the diet of harp seals in nearshore and offshore waters of 2J3KL during winter and Summer seasons were calculated from reconstructed wet weights and energy densities of prey in stomachs. Samples from all years were pooled across years to estimate an average diet for the time period. The greatest proportion of energy in the winter nearshore diet came from Arctic cod (53.85%, se=1.5), Atlantic herring (14.51%, se=1.02) and capelin (9.08%, se=0.55) (Table 3). Capelin (61.42%, se=7.6) was the largest contributor in offshore areas although there was greater variation than in nearshore areas. American plaice (12.75%, se=7.79), unidentified pleuronectidae (8.34%, se=4.72) and shrimp (7.56%, se=2.01) were also common contributors to the diet. In general, the diet among the three divisions were similar although some differences did occur (e.g. rock cod and sculpins in nearshore areas).

Arctic cod (20.31%; se=2.3), Atlantic herring (24.37%, se=2.62) and capelin (18.07%, se=1.81) also contributed the most energy to the overall nearshore diet during the summer (Table 4) although neither Arctic cod nor herring was as important in 2J as in the other two divisions. The greatest proportion of energy in summer offshore diets came from capelin (35.97%, se=6.73), pleuronectidae (32.37%, se=10.63) and sand lance (19.28%, se=4.14).

Atlantic cod contributed little to offshore diets and varied between seasons and among years in nearshore areas. No cod were present in the stomachs of offshore seals during the summer and in only two years (1990 and 1994) during the winter (Table 5). Cod were present in all nearshore samples but the proportion of prey-containing stomachs (i.e. prevalence) varied

greatly (2% - 22%) among years. Overall, cod were present in approximately 10% of the prey containing stomachs in nearshore areas.

The contribution of Atlantic cod to the harp seal diet (expressed as % energy) also varied significantly among years (Table 6). The highest mean percent of energy from Atlantic cod in nearshore summer samples occurred in 1995 and 1998, 11.13% (se=5.79) and 10.96% (se=7.39), respectively. With the exception of 1998, Atlantic cod ranged from <1% to 9% of the diet during the winter. In 1998, cod accounted for 35.3% (se=7.72) of the energy in diets of animals collected in the nearshore during the winter of 1998, most of which came from samples in 3K and 3L (Table 6). However, the coefficient of variance associated with these estimates is high, ranging from approximately 0.2 to 0.9.

The increased contribution by Atlantic cod in nearshore diets during some years does not necessarily reflect an increase in prevalence of cod in samples. For example, although the proportion of cod in the diet in the winter 1998 samples was greater than in any other year, prevalence (17.6%) was similar or less than in other years (Tables 5 and 7). Similarly the prevalence of cod in summer samples from 1995 and 1998 was less than occurred in 1990 or 1993 when the total contribution to the diet was less than 2%.

Like Atlantic cod, the prevalence of Arctic cod and capelin also varied greatly among years and areas (Table 7). There were no obvious relationships between prevalence of the three species, although the prevalence of Arctic cod in the late 1990s appears to be less than during the cold water years of the early 1990s, particularly in Division 3L. The prevalence of capelin has been lower since 1990 in the summer and winter in Division 3L and winter in 3K. In Division 2J it appears to have increased slightly during the winter since the mid 1990s.

The average weight of contents in prey containing stomachs was greater among seals collected during the winter than during the summer (Table 8). With few exceptions, this was consistent among years, particularly in Divisions 3K and 3L. Summer samples from 2J contained similar or more contents than those collected during the winter although the sample sizes for the summer period were small.

The average weight of Atlantic cod in harp seal stomachs collected during the summer was less than 50 gm in most years when expressed as an average of all stomachs (Table 8), or less than 300 gm in only those animals that ate cod were considered (Table 9). The average weight in 1995, however, was much greater due to the presence of a few large fish taken in 3K. The average weight of Atlantic cod was also much greater than average in 1996 and 1998. This appeared to be primarily due to the presence of a single seal from 3L in 1996 that contained a large amount of Atlantic cod and two individuals from 3K in 1998.

The average weight of Atlantic cod taken during the winter was generally greater than observed during the summer (Tables 8 and 9). Weights did not vary greatly among years with the exception of 1998 when a large increase was observed, particularly in Divisions 3K and 3L.

The average weights of capelin and Arctic cod in the stomachs of harp seals did not vary as much as Atlantic cod (Tables 8 and 9). With few exceptions (e.g. winter 1982), the average weight of capelin was consistent among years. The average meal of Arctic cod was generally greater than either Atlantic cod or capelin, particularly during the winter when this species is

abundant in Newfoundland waters. The lower average weights observed in 1997 and 1998 among the large sample taken in Division 3K during the winter suggests that less Arctic cod were being consumed per seal.

The proportion of seal stomachs containing Atlantic cod and the average length of the cod consumed by NAFO Unit Areas within Divisions 2J3KL is presented in Tables 10 and 11, respectively. Cod have been found in stomachs collected along the northeast coast (Unit Areas 337-342) in most years, particularly during the winter (Table 10). With the exception of a possible increase in the occurrence of cod in southern areas (337,338) in recent years, prevalence of Atlantic cod in stomachs from each unit area varied greatly with no obvious trend. Comparing the average length of cod from each unit area indicates that the observed increases in average weight reflected an increase in the length of fish that were consumed. The large increase in the length and weight of cod consumed in 1998 occurred across a number of unit areas.

Based on their average diet, consumption of capelin by harp seals in NAFO Divisions 2J3KL increased from 323,000 tonnes (95% C.I. 247,000 – 95,000 t) in 1965 to 893,000 tonnes (95% C.I. 682,000 -1,100,000 t) in 2000 (Table 12, Fig. 3). During the same period consumption of Arctic cod increased from 67,000 tonnes (95% C.I. 21,000 – 162,000 t) to 186,000 tonnes (95% C.I. 58,000 – 457,000 t; Fig. 4) and Atlantic cod rose from 13,000 tonnes (95% C.I. 5,000 – 22,000 t) to 37,000 tonnes (95% C.I. 14,000 - 62,000 t, Fig. 5).

Discussion

The objective of this study was to estimate consumption of Atlantic cod, Arctic cod and capelin by harp seals in NAFO Divisions 2J3KL with associated uncertainty. We used the same basic model structure as in previous seal consumption studies (Mohn and Bowen 1996; Stenson *et al.* 1997; Hammill and Stenson 2000). Estimates of consumption by harp seals in NAFO Divisions 2J3KL have been presented previously (Stenson *et al.* 1997; Hammill and Stenson 2000), but these estimates must be revised, sometimes substantially, as new data become available.

Based on the available data Stenson *et al.* (1997) estimated that approximately 1.2 million tonnes of Arctic cod, 620,000 tonnes of capelin and 88,000 tonnes of Atlantic cod were consumed by harp seals off the eastern coast of Newfoundland in 1994. Using revised estimates of abundance, additional diet data, and new information on the seasonal distribution of harp seals, Hammill and Stenson (2000) revised these estimates significantly. The major contributor to the change in the consumption estimates were the new data available on the relative use of nearshore and offshore areas obtained from satellite telemetry studies. The original model assumed that seals were randomly distributed across the continental shelf, but data on the movements of individual seals throughout the year (Stenson and Sjare 1997) indicated that harp seals utilized offshore areas to a much greater extent than previously thought. Including these data along with additional diet data, in the model (Hammill and Stenson 2000) resulted in significant changes in consumption estimates. Due to differences in the diets between nearshore and offshore areas, estimates of the amount of Atlantic cod and Arctic cod consumed by the slightly larger harp seal population in 1996 were reduced to 49,000 tonnes and 176,000 tonnes, respectively, while consumption of capelin was increased to 176,000 tonnes.

The estimates presented in this study further reduce the consumption of Atlantic cod while increasing the importance of capelin. Although the basic model is very similar to that presented in Hammill and Stenson (2000) some changes have been made to improve the estimates. A subset of the stomach content data used in this study data have been reported previously (Lawson and Stenson 1995, 1997; Lawson *et al.* 1995; Stenson *et al.* 1997; Hammill and Stenson 2000). However, more recent data (1996-1998) were added and the equations used to estimate the lengths of Atlantic cod, American plaice, pleuronectidae and squid from hard parts were revised. The new equations were based on additional data and/or equations derived from local data and are more appropriate for the area under study. The previous estimate incorporated a 10% 'correction factor' for unidentified prey to account for biases associated with using hard parts to identify prey. Because the degree of potential bias associated with the consumption of soft bodied prey, the digestion of small otoliths, and belly biting could not be estimated, this correction factor was removed. The largest single change in the estimates was due to the removal of some offshore samples that were obtained in the vicinity of research vessels conducting surveys for cod. Comparing catches from trawls to the species composition and size of prey found in the stomachs of seals obtained shortly after trawling had occurred suggested that some of the seals may have been feeding on discards from the vessels. Therefore, all seals (n=11) collected in the vicinity of the trawler within 12 hours of fishing were removed. This is consistent with the removal of potentially biased samples from other sources and samples collected around trawlers in other studies (e.g. South African fur seals, J. Harwood, Sea Mammal Research Unit, University of St. Andrews, St. Andrews, UK, pers. comm.). As a result, the proportion of cod in the offshore diet was reduced substantially.

In this study we provided estimates of the degree of error in the consumption due to uncertainty in the diet composition along with uncertainty in the population estimates, residency in 2J3KL and the proportion of seals found in nearshore and offshore areas. This is an improvement over the estimates presented in Stenson *et al.* (1997) which were based upon the variance in diet obtained by comparing the interannual variance in the contribution of a particular prey species. In addition to incorporating error associated with the population estimates and seasonal distribution, resampling the individual stomach contents provided a more realistic estimate of the variance in the diet of harp seals.

Uncertainty in the estimates of Arctic cod consumption was greater than for the other species. Precision of the capelin estimates was high, likely reflecting the low variance associated with the diet estimates. The estimates of Arctic cod in the nearshore diets were also precise, but the estimates for the offshore diets were much lower and had higher variance. The model is weighted towards offshore consumption because of the distribution of harp seals and, therefore, the overall uncertainty in the consumption estimates was larger. Also, the method we used allowed us to model each parameter separately, and the error associated with the proportion of the population using the offshore was not symmetrical. As a result the overall estimates of uncertainty in the estimates of Arctic cod consumption was highly skewed. It is difficult to obtain precise estimates of the contribution to the diet for prey species that are relatively small components of the diet and/or are highly variable such as Atlantic cod or Arctic cod in offshore areas. As a result, consumption estimates for these species will remain highly uncertain.

The estimates presented here are minimum estimates of the uncertainty associated with the prey consumption since we have not accounted for uncertainty in other parameters of the model such as the energy requirements of individuals or the proportion of the population that remains in the Arctic. Shelton *et al.* (1997) presented a method to include all sources of uncertainty using a resampling technique similar to the one used here to determine how the various parameters contribute to uncertainty. Although many of the parameters were taken from the consumption model described in Stenson et al. (1997), the use of different diets among runs of the model did not allow them to apply their method to the complete consumption model. Shelton *et al.* (1997) found that uncertainty associated with the population estimates had the least effect on the overall uncertainty of consumption estimates, while diet composition had the greatest effect. Although we have not quantified the contribution of each parameter to the overall uncertainty, it appears that the degree of error associated with the diet estimates is a major factor in determining the overall level of uncertainty.

One of the difficulties in incorporating additional sources of error in the model is to determine appropriate levels of uncertainty for some of the parameters. The degree of variation associated with estimates of basal metabolic rate and/or energy requirements of individuals are only now being investigated (e.g. Hunter 1999). Other parameters such as the proportion of the population that remains in the Arctic or that go into the Gulf of St. Lawrence are assumed due to the lack of relevant data. Therefore, the level of uncertainty that should be applied to these parameters is unknown. In future runs of the model we may be able to take a Baysean approach and assume a level of uncertainty on these assumptions. However, the sensitivity of the estimates to these assumptions must be determined.

The availability of annual samples from nearshore areas over a 14-year period provides an opportunity to examine interannual variation in the diet from the mid 1980s through the late 1990s. During this period, the marine environment off the coast of Newfoundland underwent dramatic changes with significant changes in water temperatures (Colbourne 2001) and the abundance of many prey species (e.g. Anderson *et al.* 1999; Carscadden *et al.* 2001; Orr *et al.* 2001; Lilly and Simpson 2000; Lilly *et al.* 2001). Prevalence and the average weight of capelin in the stomachs of harp seals collected in nearshore areas varied greatly with no obvious trends. The abundance of capelin in 2J3KL has been difficult to determine since the early 1990s although there appears to have been a southward shift in distribution, reduced size of individuals and delays in the timing of the inshore spawning migrations (Nakashima 1996; Carscadden *et al.* 1997, 2001) that may have changed the availability of capelin to seals. The decline in the proportion of seals eating Arctic cod and the average weight of Arctic cod found in seal stomachs may reflect changes in local abundance. Arctic cod were more abundant in bottom-trawls surveys carried out in Divisions 2J3KL during a period of cold water temperatures in the late 1980s and early 1990s than during the warmer water period since the mid 1990s (Lilly and Simpson 2000).

The occurrence of Atlantic cod in the diet also exhibited high variability over the study period. There was no indication of decline as may be expected given the large decrease in this cod stock (DFO 2001; Lilly *et al.* 1998, 2001). In fact, a large increase was observed in 1998. This increase appeared to be due mainly to an increase in the weight of cod being consumed by harp seals and was reflected in the ages of the fish being consumed. Lilly *et al.* (2001) found that while cod age 0 and 1 were the predominant age groups in harp seal stomachs prior to 1997, older fish (ages 3-5) were the dominant group since then with some fish as old as age 7

being consumed. The total number of fish consumed by harp seals decreased while the total biomass remained constant. Although the overall abundance of this cod stock has declined to an extremely low level, the continued consumption by harp seals may reflect local abundance. The remaining cod in this stock were primarily confined to nearshore areas in 3K and 3L by the late 1990s (Lilly *et al.* 2001), where they formed a larger proportion of the seal diet than in 2J. Poor recruitment in this stock since the early 1990s resulted in an age structure skewed towards older, larger fish and was reflected in the age of the fish consumed.

Unfortunately, little is known about the factors affecting prey selection by seals. A comparison of harp seal stomach content data collected off Newfoundland with prey abundance data collected from research trawl surveys suggests that harp seals preferentially select capelin (and possibly Arctic cod), but are neutrally selective towards Atlantic cod, American plaice and Greenland halibut (Lawson *et al.* 1998b).

Although there was a large amount of variation in prey contribution among years, we used a pooled average of the samples to estimate consumption over the study period. Stenson *et al.* (1997) compared annual estimates of harp seal consumption of Arctic cod, capelin and Atlantic cod off eastern Newfoundland between 1981 and 1994, using both annual and pooled diet composition data. Large annual changes (*e.g.* 50%-200%) in the consumption of major prey species (such as Arctic cod and capelin) were not tracked very well using a pooled average diet, suggesting that important trends in consumption were being masked. However, it was not clear if the differences observed were true changes in consumption or a consequence of sampling error. Although we do not present estimates using annual estimates in this paper, the large uncertainty associated with the estimates of Arctic cod consumption make it likely that they fall within the confidence levels of the estimates presented here. Preliminary runs using yearly estimates of Atlantic cod in the diet suggest that they are not significantly different either.

The consumption estimates presented here can be improved in a number of ways. We assumed that average daily age specific energy requirements of seals could be described by a simple equation based upon age specific body mass and constants to account for energy requirements due to activity and growth. Changes in activity and growth do occur and can have a major impact on consumption estimates (Mohn and Bowen 1996), however these changes are difficult to estimate as they are poorly documented. The estimates of body mass used (Hammill and Stenson 2000) were based on samples collected when body mass is near the annual minimum and thus underestimate total annual energy requirements, particularly during the winter period when harp seals are building energy stores for the whelping period (Chabot *et al.* 1996).

The assumption that consumption rates do not change during lactation, breeding and moulting periods, when most adults reduce feeding and rely upon energy reserves (Sergeant 1991) could lead to overestimating consumption, especially during the summer. There is also some evidence of different seasonal distributions between males and females, as well as sex-specific changes in body condition. For example, after breeding, female harp seals leave the whelping area and feed intensively (Sergeant 1991; Stenson and Hammill, unpublished data) to replace a portion of the energy reserves expended during lactation (Beck *et al.* 1993a, b; Chabot *et al.* 1996) and to prepare for the moult. Males remain near the whelping patch

(Sergeant 1991), and continue to lose mass until early April when the moult begins (Chabot *et al.* 1996).

The use of reconstructed wet weights based upon identification of hard parts recovered from stomachs result in a large variety of potential biases (e.g. see Harvey 1989; Pierce and Boyle 1991; Gales and Cheal 1992; Tollit *et al.* 1997; Bowen 2000). Most important are potential over estimation of some species (e.g. those with robust otoliths) and underestimates of other species due to differential digestion and retention rates, lack of identifiable remains from soft bodied prey, and incomplete consumption of prey such as 'belly biting' or not consuming heads. Also, determining the appropriate weights of invertebrates that may comprise an important component of the diet is very difficult (Hammill and Stenson 2000). The use of alternative measures of diet such as enumeration of all hard parts (e.g. Boyle *et al.* 1990; Cottrell *et al.* 1996), and the use of fatty acids and stable isotopes (e.g. Hobson *et al.* 1996; Iverson *et al.* 1997; Lawson and Hobson 200; Lesage *et at.* 2001) may provide additional information and should be explored further.

The greatest requirement for improving our understanding of the harp seal diet and hence the accuracy of the consumption estimates, is the need for more samples from offshore areas. Although harp seals appear to spend the majority of their time in offshore areas, only 6 percent of the over 4 400 samples are from this area and only 24 samples have been collected there since 1994. The unbalanced representation of animals between offshore and nearshore areas is due to the relative ease of collecting inshore samples by co-operating with sealers, and the lack of funds to carry out offshore sampling. Directed sampling in offshore areas is critical to improving consumption estimates for harp seals.

An improved understanding of the seasonal distribution of harp seals is also required to increase the accuracy of our consumption estimates. The residence period in Divisions 2J3KL and the seasonal movements were based on satellite telemetry data obtained from mature animals during the mid 1990s (Stenson and Sjare 1997). It is not clear if these data accurately reflect the movements of younger seals or adult seals during other time periods. The ratio of juveniles to adults in catches in nearshore areas is consistent with the proportions present in the population, suggesting that there is no obvious segregation between these two components of the population with respect to using nearshore areas (Stenson and Sjare, unpublished data). Little is known about the movements of young of the year harp seals but they are thought to migrate at different times than older animals (Sergeant 1991) and tag return data suggests that there may be incomplete mixing among the younger age classes (Warren 1991). Additional satellite telemetry studies are required in order to determine the appropriateness of the current data for estimating seasonal movements.

Assessments of fish stocks have traditionally been based on single species approaches, assuming that fishing mortality alone is responsible for variations in fish survival (Bax, 1998). Predation, however is a constant feature of marine ecosystems and may exceed fisheries harvest, particularly during periods of reduced fishing such as that currently occurring in the Northwest Atlantic. As a result, fisheries scientists are trying to understand the impact predation may be having on the population dynamics of various prey species (e.g. Mohn and Bowen 1996; Swain and Sinclair 2000; Bogstad *et al.* 2000; Carscadden *et al.* 2001; Yodzis 2001). In the waters off Newfoundland, there is concern that consumption of cod by seals may be limiting the recovery of the depleted Northern (2J3KL) cod stock (DFO 2001; Lilly et al.

2001). However, estimates of consumption by seals cannot be reconciled to current estimates of cod biomass (DFO 2001). It is hoped that this may be less of a problem once the uncertainty associated with both estimates are considered.

Although seals are estimated to consume substantial amounts of prey in Atlantic Canada (Hammill and Stenson 2000, this study), it will not be possible to assess the relative impact of seal predation on fish stock abundance until other sources of natural mortality are quantified. Multispecies predation models indicate that consumption of fish by other fish can exceed that of marine mammals (e.g. Overholtz *et al.* 1991; Trites *et al.* 1997). Dynamic, multispecies models offer the potential to fully evaluate the mortality impacts of predators (e.g. Sparre 1991; Sissenwine and Daan 1991; Punt and Butterworth 1995; Bogstad *et al.* 1997; Stefánsson *et al.* 1997), but the data requirements of these approaches are often too great to be of use in a number of areas. Less data intensive, mass-balance types of models (e.g. Christensen and Pauly 1993; Trites *et al.* 1997; Walters *et al.* 1997; Pauly *et al.* 2000; Bundy *et al. 2000*) have been used to provide insights into ecosystem structure and even to test hypotheses about the relative importance of various removal within the system (Bundy 2001). However, these models often require a large number of assumptions and do not provide an indication of the uncertainty associated with their conclusions. Data gaps are likely to continue to plague multispecies modeling attempts for some time. However, testing the sensitivity of these models to their assumptions and incorporating the uncertainty associated with the consumption estimates will provide important insights into the reliability of any conclusions that can be made about the potential impacts of predators.

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Table 1. Proportion of harp seal locations obtained from satellite telemetry (1993-1997) greater than 25 km or 50 km from headlands in 2J3KL.

Seal ID	Distance from Shore			
	>25 km		>50 km	
	Winter	Summer	Winter	Summer
93Pg1	0.83	1.00	0.65	1.00
93Pg2	0.95	1.00	0.93	1.00
95Pg1	0.97	0.90	0.84	0.86
95Pg2	0.50	0.58	0.27	0.25
95Pg3	0.97	0.94	0.89	0.89
95Pg4	1.00	1.00	1.00	1.00
95Pg5	0.12	1.00	0.12	1.00
95Pg6	1.00	0.50	1.00	0.33
95Pg7	0.78	0.98	0.73	0.95
95Pg8	0.69	0.54	0.51	0.23
95Pg9	0.87	0.91	0.85	0.84
95Pg10	0.98	0.97	0.95	0.81
95Pg11	0.90	0.52	0.70	0.48
96Pg1	1.00	1.00	1.00	1.00
96Pg2		1.00		1.00
96Pg3	1.00	1.00	1.00	1.00
96Pg4	1.00	1.00	1.00	1.00
96Pg5	1.00	1.00	1.00	1.00
96Pg6	1.00	1.00	1.00	1.00
96Pg7		1.00		1.00
96Pg8		1.00		1.00
96Pg9		1.00		1.00
96Pg10	1.00	1.00	1.00	1.00
Av.	0.87	0.91	0.81	0.85
Model	0.87	0.90		

Table 2. Numbers of reconstructed prey-containing stomachs from harp seals collected in 2J3KL, 1982 and 1986-1998, by area and season.

	2J				3K				3L				2J3KL			
	Nearshore		Offshore		Nearshore		Offshore		Nearshore		Offshore		Nearshore		Offshore	
	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter
1982	13			13	76	196							89	196		13
1986		79			99	354			1	18			100	451		
1987		71			72	259			6				78	330		
1988		89			75	133			3	8			78	230		
1989	5	45			50	142			2	3			57	190		
1990		72		20	44	99			7	5			51	176		20
1991	7	41			71	102			15	1			93	144		
1992	2	79			56	138	33		12	21	56		70	238	89	
1993	9	80			80	90	3	13	13	28	35	14	102	198	38	27
1994	14	96		2	50	90	18	17	22	26	4	24	86	212	22	43
1995		27			31	75			23	22		1	54	124		1
1996	5	69	4		32	189		4	6	44			43	302	4	4
1997		48			62	116			17	28			79	192		
1998		31			28	125	2	3	10	20	10		38	176	12	3
Total	55	827	4	35	826	2108	56	37	137	224	105	39	1018	3159	165	111

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95Pg2	0.50	0.58	0.27	0.25
95Pg3	0.97	0.94	0.89	0.89
95Pg4	1.00	1.00	1.00	1.00
95Pg5	0.12	1.00	0.12	1.00
95Pg6	1.00	0.50	1.00	0.33
95Pg7	0.78	0.98	0.73	0.95
95Pg8	0.69	0.54	0.51	0.23
95Pg9	0.87	0.91	0.85	0.84
95Pg10	0.98	0.97	0.95	0.81
95Pg11	0.90	0.52	0.70	0.48
96Pg1	1.00	1.00	1.00	1.00
96Pg2		1.00		1.00
96Pg3	1.00	1.00	1.00	1.00
96Pg4	1.00	1.00	1.00	1.00
96Pg5	1.00	1.00	1.00	1.00
96Pg6	1.00	1.00	1.00	1.00
96Pg7		1.00		1.00
96Pg8		1.00		1.00
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	Nearshore		Offshore		Nearshore		Offshore		Nearshore		Offshore		Nearshore		Offshore	
	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter
1982	13			13	76	196							89	196		13
1986		79			99	354			1	18			100	451		
1987		71			72	259			6				78	330		
1988		89			75	133			3	8			78	230		
1989	5	45			50	142			2	3			57	190		
1990		72		20	44	99			7	5			51	176		20
1991	7	41			71	102			15	1			93	144		
1992	2	79			56	138	33		12	21	56		70	238	89	
1993	9	80			80	90	3	13	13	28	35	14	102	198	38	27
1994	14	96		2	50	90	18	17	22	26	4	24	86	212	22	43
1995		27			31	75			23	22		1	54	124		1
1996	5	69	4		32	189		4	6	44			43	302	4	4
1997		48			62	116			17	28			79	192		
1998		31			28	125	2	3	10	20	10		38	176	12	3
Total	55	827	4	35	826	2108	56	37	137	224	105	39	1018	3159	165	111

Table 3. Winter diet (% energy) of harp seals sampled in the nearshore and offshore of NAFO Divisions 2J3KL, pooled over years1982, 1986-1998.

	Nearshore								Offshore							
	2J (n=827)		3K (n=2108)		3L (n=224)		2J3KL		2J (n=35)		3K (n=37)		3L (n=39)		2J3KL	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
American Plaice			0.32	0.12	2.36	2.37	0.47	0.22	9.05	8.53	30.08	15.94			12.75	7.79
Amphipod	0.01	0.01	0.41	0.08	0.16	0.10	0.34	0.06	0.15	0.09	0.92	0.45	1.40	0.67	1.11	0.39
Arctic Cod	33.65	2.91	60.04	1.71	24.07	4.46	53.85	1.5	4.04	1.88	0.67	0.35	1.07	0.26	1.09	0.23
Atlantic Cod	6.22	1.73	3.76	0.77	10.56	4.11	4.66	0.76	0.52	0.51	1.02	0.93	0.93	0.63	0.92	0.51
Atlantic Herring	0.77	0.36	14.06	1.14	35.81	4.63	14.51	1.02								
Bird	0.74	0.42	<0.01	<0.01			0.08	0.05								
Capelin	20.07	2.42	7.02	0.53	14.29	2.46	9.08	0.55	1.92	1.55	41.07	12.73	84.44	4.54	61.42	7.6
Euphausiid	0.06	0.03	0.45	0.07	1.82	0.38	0.52	0.07								
Gadoid sp.	1.94	1.46	0.07	0.04			0.28	0.17			0.01	0.01	0.01	0.01	0.01	0.01
Gadus sp.	5.67	1.18	0.23	0.07	0.01	0.01	0.81	0.14								
Greenland Halibut	2.24	1.84	0.96	0.27	0.09	0.09	1	0.3			3.58	2.10	3.15	1.13	3.15	1.03
Lumpfish			<0.01	<0.01												
Mysid	0.20	0.06	0.03	0.01	<0.01	<0.01	0.04	0.01			<0.01	<0.01				
Other Fish	5.63	1.22	6.27	0.90	3.21	1.20	5.94	0.72	2.21	1.36	2.44	1.62	2.21	1.10	2.27	0.86
Other Invert	0.02	0.01	0.02	0.01			0.02	0.01					<0.01	<0.01		
Pleuronectidae	0.07	0.04	1.35	0.38	6.42	3.95	1.67	0.47	0.26	0.25	14.14	9.91	4.14	3.96	8.34	4.72
Redfish sp.	0.01	0.01	0.01	0.01	0.02	0.02	0.01		0.03	0.03	0.01	0.01	0.81	0.79	0.44	0.43
Rock Cod	7.19	1.67	1.90	0.43	0.06	0.06	2.34	0.4								
Salmon																
Sand Lance	0.94	0.38	0.42	0.09	0.05	0.05	0.44	0.09								
Sculpin	13.10	3.76	0.69	0.18	0.05	0.03	2.08	0.52	0.22	0.24	0.25	0.18	0.15	0.08	0.19	0.08
Shrimp	1.05	0.29	1.37	0.14	0.97	0.33	1.31	0.12	81.14	9.51	4.70	2.06	1.15	0.61	7.56	2.01
Smelt	0.03	0.01	0.03	0.01			0.02	0.01								
Squid	0.02	0.02	0.49	0.09	0.06	0.02	0.4	0.07	0.45	0.36	1.11	0.53	0.54	0.23	0.77	0.25
White Hake	0.37	0.15	0.10	0.07			0.12	0.06								

Table 4. Summer diet (% energy) of harp seals sampled in the nearshore and offshore of NAFO Divisions 2J3KL, pooled over years1982, 1986-1998.

	Nearshore								Offshore							
	2J (n=55)		3K (n=826)		3L (n=137)		2J3KL		2J (n=4)		3K (n=56)		3L (n=105)		2J3KL	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
American Plaice			4.45	1.65	4.49	3.58	4.41	1.46			1.48	1.57	3.14	3.16	2.57	2.16
Amphipod	0.03	0.04	0.20	0.08	0.02	0.01	0.17	0.06			2.27	1.10	0.27	0.17	0.74	0.24
Arctic Cod	1.82	0.94	21.93	2.66	14.79	5.01	20.31	2.3	1.34	0.95	1.13	0.50	0.12	0.09	0.41	0.15
Atlantic Cod	9.95	6.49	2.91	0.87	6.59	2.25	3.69	0.83								
Atlantic Herring			22.37	2.99	41.45	5.55	24.37	2.62								
Bird	<0.01	<0.01									0.01	0.01				
Capelin	58.41	7.73	17.29	2.05	14.01	3.76	18.07	1.81			56.42	16.89	30.98	6.65	35.97	6.73
Euphausiid	2.44	1.16	2.94	0.41	5.76	1.38	3.34	0.39			<0.01	<0.01			0	
Gadoid sp.			0.08	0.04	0.01	0.01	0.07	0.04					<0.01	<0.01	0	
Gadus sp.	3.21	1.56	0.29	0.11	0.04	0.04	0.34	0.11								
Greenland Halibut			1.90	0.67	0.28	0.29	1.62	0.55			7.23	4.20	2.80	2.90	3.99	2.26
Lumpfish																
Mysid			0.04	0.02	0.22	0.22	0.07	0.04								
Other Fish	0.99	0.58	12.89	5.19	1.27	0.50	10.63	4.39	4.74	3.36	1.56	1.60	0.13	0.11	0.63	0.38
Other Invert	0.10	0.08	0.18	0.16			0.14	0.11			<0.01	<0.01	0.03	0.02	0.02	0.01
Pleuronectidae			5.54	1.60	9.82	4.13	6.15	1.51			24.97	21.31	34.18	12.40	32.37	10.63
Redfish sp.			0.68	0.45			0.57	0.38								
Rock Cod	11.86	4.99	1.20	0.63			1.34	0.55								
Salmon			0.13	0.13			0.11	0.11								
Sand Lance	5.53	3.83	0.11	0.07			0.27	0.14					27.40	6.14	19.28	4.14
Sculpin	5.50	3.50	0.73	0.45	0.02	0.02	0.78	0.38	0.39	0.28	0.02	0.02	0.15	0.06	0.13	0.05
Shrimp	0.14	0.08	2.84	0.40	1.19	0.58	2.5	0.32	93.53	4.58	4.38	2.71	0.61	0.58	3.64	1.9
Smelt																
Squid			1.30	0.28	0.05	0.03	1.06	0.23			0.52	0.31	0.17	0.11	0.24	0.1
White Hake																

Table 3. Winter diet (% energy) of harp seals sampled in the nearshore and offshore of NAFO Divisions 2J3KL, pooled over years1982, 1986-1998.

	Nearshore								Offshore							
	2J (n=827)		3K (n=2108)		3L (n=224)		2J3KL		2J (n=35)		3K (n=37)		3L (n=39)		2J3KL	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
American Plaice			0.32	0.12	2.36	2.37	0.47	0.22	9.05	8.53	30.08	15.94			12.75	7.79
Amphipod	0.01	0.01	0.41	0.08	0.16	0.10	0.34	0.06	0.15	0.09	0.92	0.45	1.40	0.67	1.11	0.39
Arctic Cod	33.65	2.91	60.04	1.71	24.07	4.46	53.85	1.5	4.04	1.88	0.67	0.35	1.07	0.26	1.09	0.23
Atlantic Cod	6.22	1.73	3.76	0.77	10.56	4.11	4.66	0.76	0.52	0.51	1.02	0.93	0.93	0.63	0.92	0.51
Atlantic Herring	0.77	0.36	14.06	1.14	35.81	4.63	14.51	1.02								
Bird	0.74	0.42	<0.01	<0.01			0.08	0.05								
Capelin	20.07	2.42	7.02	0.53	14.29	2.46	9.08	0.55	1.92	1.55	41.07	12.73	84.44	4.54	61.42	7.6
Euphausiid	0.06	0.03	0.45	0.07	1.82	0.38	0.52	0.07								
Gadoid sp.	1.94	1.46	0.07	0.04			0.28	0.17			0.01	0.01	0.01	0.01	0.01	0.01
Gadus sp.	5.67	1.18	0.23	0.07	0.01	0.01	0.81	0.14								
Greenland Halibut	2.24	1.84	0.96	0.27	0.09	0.09	1	0.3			3.58	2.10	3.15	1.13	3.15	1.03
Lumpfish			<0.01	<0.01												
Mysid	0.20	0.06	0.03	0.01	<0.01	<0.01	0.04	0.01			<0.01	<0.01				
Other Fish	5.63	1.22	6.27	0.90	3.21	1.20	5.94	0.72	2.21	1.36	2.44	1.62	2.21	1.10	2.27	0.86
Other Invert	0.02	0.01	0.02	0.01			0.02	0.01					<0.01	<0.01		
Pleuronectidae	0.07	0.04	1.35	0.38	6.42	3.95	1.67	0.47	0.26	0.25	14.14	9.91	4.14	3.96	8.34	4.72
Redfish sp.	0.01	0.01	0.01	0.01	0.02	0.02	0.01		0.03	0.03	0.01	0.01	0.81	0.79	0.44	0.43
Rock Cod	7.19	1.67	1.90	0.43	0.06	0.06	2.34	0.4								
Salmon																
Sand Lance	0.94	0.38	0.42	0.09	0.05	0.05	0.44	0.09								
Sculpin	13.10	3.76	0.69	0.18	0.05	0.03	2.08	0.52	0.22	0.24	0.25	0.18	0.15	0.08	0.19	0.08
Shrimp	1.05	0.29	1.37	0.14	0.97	0.33	1.31	0.12	81.14	9.51	4.70	2.06	1.15	0.61	7.56	2.01
Smelt	0.03	0.01	0.03	0.01			0.02	0.01								
Squid	0.02	0.02	0.49	0.09	0.06	0.02	0.4	0.07	0.45	0.36	1.11	0.53	0.54	0.23	0.77	0.25
White Hake	0.37	0.15	0.10	0.07			0.12	0.06								

Table 4. Summer diet (% energy) of harp seals sampled in the nearshore and offshore of NAFO Divisions 2J3KL, pooled over years1982, 1986-1998.

	Nearshore								Offshore							
	2J (n=55)		3K (n=826)		3L (n=137)		2J3KL		2J (n=4)		3K (n=56)		3L (n=105)		2J3KL	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
American Plaice			4.45	1.65	4.49	3.58	4.41	1.46			1.48	1.57	3.14	3.16	2.57	2.16
Amphipod	0.03	0.04	0.20	0.08	0.02	0.01	0.17	0.06			2.27	1.10	0.27	0.17	0.74	0.24
Arctic Cod	1.82	0.94	21.93	2.66	14.79	5.01	20.31	2.3	1.34	0.95	1.13	0.50	0.12	0.09	0.41	0.15
Atlantic Cod	9.95	6.49	2.91	0.87	6.59	2.25	3.69	0.83								
Atlantic Herring			22.37	2.99	41.45	5.55	24.37	2.62								
Bird	<0.01	<0.01									0.01	0.01				
Capelin	58.41	7.73	17.29	2.05	14.01	3.76	18.07	1.81			56.42	16.89	30.98	6.65	35.97	6.73
Euphausiid	2.44	1.16	2.94	0.41	5.76	1.38	3.34	0.39			<0.01	<0.01			0	
Gadoid sp.			0.08	0.04	0.01	0.01	0.07	0.04					<0.01	<0.01	0	
Gadus sp.	3.21	1.56	0.29	0.11	0.04	0.04	0.34	0.11								
Greenland Halibut			1.90	0.67	0.28	0.29	1.62	0.55			7.23	4.20	2.80	2.90	3.99	2.26
Lumpfish																
Mysid			0.04	0.02	0.22	0.22	0.07	0.04								
Other Fish	0.99	0.58	12.89	5.19	1.27	0.50	10.63	4.39	4.74	3.36	1.56	1.60	0.13	0.11	0.63	0.38
Other Invert	0.10	0.08	0.18	0.16			0.14	0.11			<0.01	<0.01	0.03	0.02	0.02	0.01
Pleuronectidae			5.54	1.60	9.82	4.13	6.15	1.51			24.97	21.31	34.18	12.40	32.37	10.63
Redfish sp.			0.68	0.45			0.57	0.38								
Rock Cod	11.86	4.99	1.20	0.63			1.34	0.55								
Salmon			0.13	0.13			0.11	0.11								
Sand Lance	5.53	3.83	0.11	0.07			0.27	0.14					27.40	6.14	19.28	4.14
Sculpin	5.50	3.50	0.73	0.45	0.02	0.02	0.78	0.38	0.39	0.28	0.02	0.02	0.15	0.06	0.13	0.05
Shrimp	0.14	0.08	2.84	0.40	1.19	0.58	2.5	0.32	93.53	4.58	4.38	2.71	0.61	0.58	3.64	1.9
Smelt																
Squid			1.30	0.28	0.05	0.03	1.06	0.23			0.52	0.31	0.17	0.11	0.24	0.1
White Hake																

Table 5. Prevalence (% of prey containing stomachs) of Atlantic cod in samples collected in NAFO Divisions in 2J3KL in years1982, 1986-1998. Sample sizes are given in parentheses.

	2J3KL			
	Nearshore		Offshore	
	Summer	Winter	Summer	Winter
1982	2.2 (89)	2.6 (196)		0 (13)
1986	8.0 (100)	9.1 451)		
1987	7.7 (78)	7.6 (330)		
1988	6.4 (78)	13.0 (230)		
1989	3.5 (57)	22.1 (190)		
1990	19.6 (51)	13.1 (176)		5.0 (20)
1991	7.5 (93)	10.4 (144)		
1992	10.0 (70)	12.2 (238)	0 (89)	
1993	15.7 (102)	16.7 (198)	0 (38)	0 (27)
1994	15.1 (86)	16.0 (212)	0 (22)	11.6 (43)
1995	14.8 (54)	20.2 (124)		0 (1)
1996	13.9 (43)	6.0 (302)	0 (4)	0 (4)
1997	10.1 (79)	8.3 (192)		
1998	15.7 (38)	17.6 (176)	0 (12)	0 (3)
Total	10.2 (1018)	11.6 (3159)	0 (165)	5.4 (111)

Table 6. Mean (SE) contribution of Atlantic cod (%energy) in harp seal diets in NAFO Divisions 2J3KL, by area and season.

	2J				3K				3L				2J3KL			
	Nearshore		Offshore		Nearshore		Offshore		Nearshore		Offshore		Nearshore		Offshore	
Year	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter
1982	0			0	1(1)	0.09 (0.06)							0.98 (1.03)	0.03 (0.03)		0
1986		2.03 (1.53)			1.25 (0.58)	0.41 (0.12)				1.01 (0.79)			1.41 (0.6)	0.49 (0.14)		
1987		0.47 (0.48)			2.15 (2.05)	1.31 (0.74)			11.79 (9.72)				1.98 (1.88)	1.25 (0.69)		
1988		8.19 (4.39)			0.77 (0.41)	0.52 (0.18)				3.09 (2.45)			0.67 (0.36)	2.23 (1.02)		
1989	0	2.04 (0.9)			0.86 (0.65)	2.12 (0.67)							0.57 (0.44)	1.99 (0.64)		
1990		21.25 (12.59)		0.84 (0.89)	2.24 (1.42)	2.99 (1.34)				0			1.59 (0.97)	6.06 (2.81)		0.79 (0.85)
1991	5.05 (5.45)	16.07 (11.48)			0.19 (0.15)	3.9 (2.29)			0.81 (0.65)				0.50 (0.26)	4.70 (2.23)		
1992		22.16 (11.0)			0.89 (0.65)	7.17 (3.12)	0	0		2.52 (1.19)	0		0.81 (0.58)	8.92 (2.91)	0	
1993	3 (1.97)	14.29 (10.1)			2.91 (1.24)	0.9 (0.51)	0	0	5.56 (2.94)	0.45 (0.32)	0	0	0.83 (0.56)	2.26 (0.94)	0	0
1994	23.33 (15.11)	4.36 (2.18)		0	1.41 (1.52)	2.01 (0.85)	0	2.06 (1.74)	9.48 (6.81)	0.12 (0.12)	0	1.59 (1.05)	6.66 (3.54)	2.41 0.77)	0	1.71 (0.9)
1995		0.55 (0.35)			11.53 (6.95)	4.19 (1.89)			8.54 (2.48)	12.4 (7.42)		0	11.13 (5.79)	5.33 (1.91)		
1996	0	0	0		7.51 (6.21)	0.8 (0.43)		0	25.99 (23.3)	10.44 (4.32)			9.92 (6.15)	2.56 (0.99)	0	0
1997		0			3.06 (2.50)	5.15 (1.91)			0.95 (0.84)	5.56 (5.43)			2.92 (2.33)	4.29 (1.71)		
1998		2.24 (2.17)			10.32 (9.07)	40.35 (8.80)	0	0	14.09 (12.12)	36.97 (17.8)			10.96 (7.39)	35.33 (7.72)		0

Table 5. Prevalence (% of prey containing stomachs) of Atlantic cod in samples collected in NAFO Divisions in 2J3KL in years1982, 1986-1998. Sample sizes are given in parentheses.

	2J3KL			
	Nearshore		Offshore	
	Summer	Winter	Summer	Winter
1982	2.2 (89)	2.6 (196)		0 (13)
1986	8.0 (100)	9.1 451)		
1987	7.7 (78)	7.6 (330)		
1988	6.4 (78)	13.0 (230)		
1989	3.5 (57)	22.1 (190)		
1990	19.6 (51)	13.1 (176)		5.0 (20)
1991	7.5 (93)	10.4 (144)		
1992	10.0 (70)	12.2 (238)	0 (89)	
1993	15.7 (102)	16.7 (198)	0 (38)	0 (27)
1994	15.1 (86)	16.0 (212)	0 (22)	11.6 (43)
1995	14.8 (54)	20.2 (124)		0 (1)
1996	13.9 (43)	6.0 (302)	0 (4)	0 (4)
1997	10.1 (79)	8.3 (192)		
1998	15.7 (38)	17.6 (176)	0 (12)	0 (3)
Total	10.2 (1018)	11.6 (3159)	0 (165)	5.4 (111)

Table 6. Mean (SE) contribution of Atlantic cod (%energy) in harp seal diets in NAFO Divisions 2J3KL, by area and season.

	2J				3K				3L				2J3KL			
	Nearshore		Offshore		Nearshore		Offshore		Nearshore		Offshore		Nearshore		Offshore	
Year	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter
1982	0			0	1(1)	0.09							0.98	0.03		0
						(0.06)							(1.03)	(0.03)		
1986		2.03			1.25	0.41				1.01			1.41	0.49		
		(1.53)			(0.58)	(0.12)				(0.79)			(0.6)	(0.14)		
1987		0.47			2.15	1.31			11.79				1.98	1.25		
		(0.48)			(2.05)	(0.74)			(9.72)				(1.88)	(0.69)		
1988		8.19			0.77	0.52				3.09			0.67	2.23		
		(4.39)			(0.41)	(0.18)				(2.45)			(0.36)	(1.02)		
1989	0	2.04			0.86	2.12							0.57	1.99		
		(0.9)			(0.65)	(0.67)							(0.44)	(0.64)		
1990		21.25		0.84	2.24	2.99				0			1.59	6.06		0.79
		(12.59)		(0.89)	(1.42)	(1.34)							(0.97)	(2.81)		(0.85)
1991	5.05	16.07			0.19	3.9			0.81				0.50	4.70		
	(5.45)	(11.48)			(0.15)	(2.29)			(0.65)				(0.26)	(2.23)		
1992		22.16			0.89	7.17	0	0		2.52	0		0.81	8.92	0	
		(11.0)			(0.65)	(3.12)				(1.19)			(0.58)	(2.91)		
1993	3 (1.97)	14.29			2.91	0.9	0	0	5.56	0.45	0	0	0.83	2.26	0	0
		(10.1)			(1.24)	(0.51)			(2.94)	(0.32)			(0.56)	(0.94)		
1994	23.33	4.36		0	1.41	2.01	0	2.06	9.48	0.12	0	1.59	6.66	2.41	0	1.71
	(15.11)	(2.18)			(1.52)	(0.85)		(1.74)	(6.81)	(0.12)		(1.05)	(3.54)	0.77)		(0.9)
1995		0.55			11.53	4.19			8.54	12.4		0	11.13	5.33		
		(0.35)			(6.95)	(1.89)			(2.48)	(7.42)			(5.79)	(1.91)		
1996	0	0	0		7.51	0.8		0	25.99	10.44			9.92	2.56	0	0
					(6.21)	(0.43)			(23.3)	(4.32)			(6.15)	(0.99)		
1997		0			3.06	5.15			0.95	5.56			2.92	4.29		
					(2.50)	(1.91)			(0.84)	(5.43)			(2.33)	(1.71)		
1998		2.24			10.32	40.35	0	0	14.09	36.97			10.96	35.33		0
		(2.17)			(9.07)	(8.80)			(12.12)	(17.8)			(7.39)	(7.72)		

Table 7. Number of harp seals sampled in nearshore areas of NAFO Divisions 2J3KL and prevalence (% of samples) of Atlantic cod, Arctic cod, and Capelin.

	2J				3K				3L				2J3KL			
	N	Atlantic Cod	Arctic Cod	Capelin	N	Atlantic Cod	Arctic Cod	Capelin	N	Atlantic Cod	Arctic Cod	Capelin	N	Atlantic Cod	Arctic Cod	Capelin
Summer																
1982	13	0.00	15.38	0.00	76	2.63	22.37	63.16					89	2.25	21.35	53.93
1986					99	7.07	67.68	23.23	1	100.00	100.00	100.00	100	8.00	68.00	24.00
1987					72	8.33	26.39	5.56	6	0.00	0.00	16.67	78	7.69	24.36	6.41
1988					75	6.67	49.33	42.67	3	0.00	33.33	33.33	78	6.41	48.72	42.31
1989	5	0.00	60.00	100.00	50	4.00	22.00	8.00	2	0.00	0.00	100.00	57	3.51	24.56	19.30
1990					44	22.73	61.36	47.73	7	0.00	28.57	100.00	51	19.61	56.86	54.90
1991	7	14.29	28.57	85.71	71	2.82	38.03	26.76	15	26.67	73.33	66.67	93	7.53	43.01	37.63
1992	2	0.00	0.00	50.00	56	12.50	60.71	42.86	12	0.00	33.33	33.33	70	10.00	54.29	41.43
1993	9	44.44	33.33	77.78	80	11.25	48.75	28.75	13	23.08	7.69	7.69	102	15.69	42.16	30.39
1994	14	57.14	7.14	100.00	50	4.00	46.00	48.00	22	13.64	63.64	9.09	86	15.12	44.19	46.51
1995					31	12.90	70.97	38.71	23	17.39	17.39	17.39	54	14.81	48.15	29.63
1996	5	0.00	0.00	100.00	32	15.63	3.13	37.50	6	16.67	0.00	0.00	43	13.95	2.33	39.53
1997					62	9.68	40.32	64.52	17	11.76	0.00	11.76	79	10.13	31.65	53.16
1998					28	7.14	25.00	50.00	10	40.00	10.00	40.0	38	15.79	21.05	47.37
Totals	55	23.64	20.00	69.09	826	8.35	43.10	36.32	137	16.06	28.47	28.47	1018	10.22	39.88	37.03
Winter																
1982					196	2.56	31.79	91.28					196	2.56	31.79	91.28
1986	79	7.59	70.89	7.59	354	9.32	85.31	20.34	18	11.11	72.22	77.78	451	9.09	82.26	20.40
1987	71	4.23	61.97	15.49	259	8.49	78.38	6.18					330	7.58	74.85	8.18
1988	89	4.49	76.40	31.46	133	16.54	81.95	32.33	8	50.00	87.50	75.00	230	13.04	80.00	33.48
1989	45	28.89	86.67	31.11	142	20.42	80.99	52.11	3	0.00	100.00	66.67	190	22.11	82.63	47.37
1990	72	6.94	62.50	38.89	99	18.18	71.72	21.21	5	0.00	40.00	100.00	176	13.07	67.05	30.68
1991	41	4.88	39.02	21.95	102	11.76	71.57	12.75	1	100.00	100.00	100.00	144	10.42	62.50	15.97
1992	79	8.86	34.18	16.46	138	12.32	34.78	6.52	21	23.81	71.43	61.90	238	12.18	37.82	14.71
1993	80	28.75	43.75	16.25	90	8.89	63.33	4.44	28	7.14	82.14	53.57	198	16.67	58.08	16.16
1994	96	15.63	46.88	34.38	90	20.00	75.56	7.78	26	3.85	38.46	30.77	212	16.04	58.02	22.64
1995	27	18.52	62.96	51.85	75	20.00	66.67	16.00	22	22.73	59.09	45.45	124	20.16	64.52	29.03
1996	69	0.00	65.22	52.17	189	4.76	57.67	10.58	44	20.45	50.00	11.36	302	5.96	58.28	20.20
1997	48	0.00	85.42	43.75	116	11.21	44.83	6.03	28	10.71	39.29	39.29	192	8.33	54.17	20.31
1998	31	3.23	67.74	77.42	125	17.60	31.20	17.60	20	40.00	35.00	5.00	176	17.61	38.07	26.70
Totals	827	10.16	60.34	30.23	2108	11.53	64.42	23.67	224	17.86	56.70	40.63	3159	11.62	62.80	26.59

Table 8. Average weight (gm) of Atlantic cod, Arctic cod, Capelin, and Total Contents in samples collected in nearshore areas of NAFO Division 2J3KL.

	2J					3K					3L					2J3KL				
	N	Atlantic Cod	Arctic Cod	Capelin	Total Contents	N	Atlantic Cod	Arctic Cod	Capelin	Total Contents	N	Atlantic Cod	Arctic Cod	Capelin	Total Contents	N	Atlantic Cod	Arctic Cod	Capelin	Total Contents
Summer																				
1982	13	0	3.65	0	51.83	76	4.30	14.33	178.42	234.32						89	3.67	12.77	152.36	207.66
1986						99	10.76	448.63	69.48	689.80	1	151.19	22.90	125.66	299.75	100	12.16	444.37	70.04	685.90
1987						72	12.66	63.36	2.43	500.32	6	0	0	8.10	81.05	78	11.69	58.49	2.87	468.07
1988						75	3.66	67.13	188.83	299.47	3	0	7.80	508.47	973.30	78	3.52	64.85	201.12	325.39
1989	5	0	11.20	283.09	294.29	50	1.39	6.97	10.32	136.94	2	0	0	481.55	481.55	57	1.22	7.10	50.78	162.83
1990						44	12.84	312.68	21.51	470.47	7	0	45.91	598.15	725.34	51	11.08	276.06	100.66	505.45
1991	7	29.73	3.65	208.82	405.84	71	2.15	253.44	21.03	785.79	15	12.54	878.37	110.26	1413.83	93	5.90	335.43	49.56	858.49
1992	2	0	0	273.30	541.95	56	13.67	199.21	101.41	1336.60	12	0	118.77	11.55	263.81	70	10.94	179.73	90.92	1129.99
1993	9	13.29	9.14	148.09	325.63	80	26.78	282.19	36.26	737.74	13	127.05	1.56	0.55	1523.15	102	38.37	222.33	41.58	801.48
1994	14	187.06	18.54	211.23	548.07	50	13.44	187.44	104.44	846.58	22	124.91	104.88	0.52	696.97	86	70.22	138.82	95.24	759.71
1995						31	233.88	329.26	33.48	1276.40	23	54.87	13.96	21.98	440.54	54	157.64	194.97	28.58	920.39
1996	5	0	0	194.12	724.59	32	67.31	1.72	104.92	770.58	6	313.96	0	0	735.54	43	93.90	1.28	100.65	760.34
1997						62	34.29	34.27	97.83	700.58	17	3.36	0	9.66	205.13	79	27.63	26.90	78.86	593.96
1998						28	115.80	5.38	73.08	763.14	10	91.83	3.37	12.72	428.54	38	109.49	4.85	57.20	675.09
Total	55	53.57	8.56	157.90	369.03	826	26.29	172.93	77.53	645.46	137	64.67	128.84	69.04	668.41	1018	32.93	158.12	80.73	633.61
Winter																				
1982						195	0.44	8.30	229.33	272.52						195	0.44	8.30	229.33	272.52
1986	79	9.22	361.10	2.78	390.24	354	6.81	1214.85	18.92	1434.28	18	5.45	28.38	221.74	313.73	451	7.18	1017.95	24.19	1206.68
1987	71	2.03	170.44	8.71	464.64	259	22.24	1117.39	1.55	1406.60						330	17.89	913.65	3.09	1203.94
1988	89	45.93	277.06	12.27	459.36	133	7.07	752.78	84.34	1062.12	8	12.54	101.54	146.28	300.10	230	22.30	546.05	58.61	802.37
1989	45	7.14	197.36	34.00	310.08	142	28.16	653.66	162.90	1019.13	3	0	1461.43	183.01	1644.44	190	22.74	558.34	132.69	861.07
1990	72	108.10	100.74	32.11	408.90	99	53.83	989.52	35.26	1486.58	5	0	36.35	446.67	517.90	176	74.50	598.85	45.66	1018.19
1991	41	33.52	19.20	4.43	179.91	102	44.45	664.56	4.29	936.41	1	34.14	538.66	125.46	853.53	144	41.27	479.94	5.17	720.44
1992	79	43.23	13.72	28.29	147.19	138	41.39	179.60	12.75	423.85	21	19.00	68.40	126.65	535.17	238	40.03	114.73	27.96	341.84
1993	80	44.45	15.94	17.70	305.01	90	14.68	1063.93	3.91	1397.89	28	7.23	826.27	152.35	1357.60	198	25.65	606.89	30.47	950.62
1994	96	22.88	36.26	42.68	434.53	90	26.83	698.80	4.15	986.92	26	1.28	149.98	66.14	607.32	212	21.91	331.47	29.20	690.23
1995	27	1.98	84.28	113.48	256.80	75	51.23	602.29	7.38	918.69	22	124.71	214.40	34.11	896.72	124	53.54	420.68	35.22	770.67
1996	69	0	76.51	142.72	499.54	189	13.64	721.67	19.47	1197.62	44	151.13	321.81	27.17	1084.42	302	30.56	516.01	48.75	1021.63
1997	48	0	313.61	71.04	516.90	116	46.13	211.08	0.82	655.44	28	86.66	420.65	95.03	1185.88	192	40.51	267.27	32.11	698.16
1998	31	18.69	171.48	299.65	520.56	125	493.62	108.47	14.89	1040.86	20	950.35	36.45	44.05	1627.67	176	461.87	111.38	68.36	1015.90
Total	827	29.31	140.23	47.54	381.58	2108	50.28	703.42	46.87	1057.11	224	141.49	295.91	99.12	958.33	3159	51.26	527.09	50.75	873.26

Table 7. Number of harp seals sampled in nearshore areas of NAFO Divisions 2J3KL and prevalence (% of samples) of Atlantic cod, Arctic cod, and Capelin.

	2J				3K				3L				2J3KL			
	N	Atlantic Cod	Arctic Cod	Capelin	N	Atlantic Cod	Arctic Cod	Capelin	N	Atlantic Cod	Arctic Cod	Capelin	N	Atlantic Cod	Arctic Cod	Capelin
Summer																
1982	13	0.00	15.38	0.00	76	2.63	22.37	63.16					89	2.25	21.35	53.93
1986					99	7.07	67.68	23.23	1	100.00	100.00	100.00	100	8.00	68.00	24.00
1987					72	8.33	26.39	5.56	6	0.00	0.00	16.67	78	7.69	24.36	6.41
1988					75	6.67	49.33	42.67	3	0.00	33.33	33.33	78	6.41	48.72	42.31
1989	5	0.00	60.00	100.00	50	4.00	22.00	8.00	2	0.00	0.00	100.00	57	3.51	24.56	19.30
1990					44	22.73	61.36	47.73	7	0.00	28.57	100.00	51	19.61	56.86	54.90
1991	7	14.29	28.57	85.71	71	2.82	38.03	26.76	15	26.67	73.33	66.67	93	7.53	43.01	37.63
1992	2	0.00	0.00	50.00	56	12.50	60.71	42.86	12	0.00	33.33	33.33	70	10.00	54.29	41.43
1993	9	44.44	33.33	77.78	80	11.25	48.75	28.75	13	23.08	7.69	7.69	102	15.69	42.16	30.39
1994	14	57.14	7.14	100.00	50	4.00	46.00	48.00	22	13.64	63.64	9.09	86	15.12	44.19	46.51
1995					31	12.90	70.97	38.71	23	17.39	17.39	17.39	54	14.81	48.15	29.63
1996	5	0.00	0.00	100.00	32	15.63	3.13	37.50	6	16.67	0.00	0.00	43	13.95	2.33	39.53
1997					62	9.68	40.32	64.52	17	11.76	0.00	11.76	79	10.13	31.65	53.16
1998					28	7.14	25.00	50.00	10	40.00	10.00	40.0	38	15.79	21.05	47.37
Totals	55	23.64	20.00	69.09	826	8.35	43.10	36.32	137	16.06	28.47	28.47	1018	10.22	39.88	37.03
Winter																
1982					196	2.56	31.79	91.28					196	2.56	31.79	91.28
1986	79	7.59	70.89	7.59	354	9.32	85.31	20.34	18	11.11	72.22	77.78	451	9.09	82.26	20.40
1987	71	4.23	61.97	15.49	259	8.49	78.38	6.18					330	7.58	74.85	8.18
1988	89	4.49	76.40	31.46	133	16.54	81.95	32.33	8	50.00	87.50	75.00	230	13.04	80.00	33.48
1989	45	28.89	86.67	31.11	142	20.42	80.99	52.11	3	0.00	100.00	66.67	190	22.11	82.63	47.37
1990	72	6.94	62.50	38.89	99	18.18	71.72	21.21	5	0.00	40.00	100.00	176	13.07	67.05	30.68
1991	41	4.88	39.02	21.95	102	11.76	71.57	12.75	1	100.00	100.00	100.00	144	10.42	62.50	15.97
1992	79	8.86	34.18	16.46	138	12.32	34.78	6.52	21	23.81	71.43	61.90	238	12.18	37.82	14.71
1993	80	28.75	43.75	16.25	90	8.89	63.33	4.44	28	7.14	82.14	53.57	198	16.67	58.08	16.16
1994	96	15.63	46.88	34.38	90	20.00	75.56	7.78	26	3.85	38.46	30.77	212	16.04	58.02	22.64
1995	27	18.52	62.96	51.85	75	20.00	66.67	16.00	22	22.73	59.09	45.45	124	20.16	64.52	29.03
1996	69	0.00	65.22	52.17	189	4.76	57.67	10.58	44	20.45	50.00	11.36	302	5.96	58.28	20.20
1997	48	0.00	85.42	43.75	116	11.21	44.83	6.03	28	10.71	39.29	39.29	192	8.33	54.17	20.31
1998	31	3.23	67.74	77.42	125	17.60	31.20	17.60	20	40.00	35.00	5.00	176	17.61	38.07	26.70
Totals	827	10.16	60.34	30.23	2108	11.53	64.42	23.67	224	17.86	56.70	40.63	3159	11.62	62.80	26.59

Table 8. Average weight (gm) of Atlantic cod, Arctic cod, Capelin, and Total Contents in samples collected in nearshore areas of NAFO Division 2J3KL.

	2J					3K					3L					2J3KL				
	N	Atlantic Cod	Arctic Cod	Capelin	Total Contents	N	Atlantic Cod	Arctic Cod	Capelin	Total Contents	N	Atlantic Cod	Arctic Cod	Capelin	Total Contents	N	Atlantic Cod	Arctic Cod	Capelin	Total Contents
Summer																				
1982	13	0	3.65	0	51.83	76	4.30	14.33	178.42	234.32						89	3.67	12.77	152.36	207.66
1986						99	10.76	448.63	69.48	689.80	1	151.19	22.90	125.66	299.75	100	12.16	444.37	70.04	685.90
1987						72	12.66	63.36	2.43	500.32	6	0	0	8.10	81.05	78	11.69	58.49	2.87	468.07
1988						75	3.66	67.13	188.83	299.47	3	0	7.80	508.47	973.30	78	3.52	64.85	201.12	325.39
1989	5	0	11.20	283.09	294.29	50	1.39	6.97	10.32	136.94	2	0	0	481.55	481.55	57	1.22	7.10	50.78	162.83
1990						44	12.84	312.68	21.51	470.47	7	0	45.91	598.15	725.34	51	11.08	276.06	100.66	505.45
1991	7	29.73	3.65	208.82	405.84	71	2.15	253.44	21.03	785.79	15	12.54	878.37	110.26	1413.83	93	5.90	335.43	49.56	858.49
1992	2	0	0	273.30	541.95	56	13.67	199.21	101.41	1336.60	12	0	118.77	11.55	263.81	70	10.94	179.73	90.92	1129.99
1993	9	13.29	9.14	148.09	325.63	80	26.78	282.19	36.26	737.74	13	127.05	1.56	0.55	1523.15	102	38.37	222.33	41.58	801.48
1994	14	187.06	18.54	211.23	548.07	50	13.44	187.44	104.44	846.58	22	124.91	104.88	0.52	696.97	86	70.22	138.82	95.24	759.71
1995						31	233.88	329.26	33.48	1276.40	23	54.87	13.96	21.98	440.54	54	157.64	194.97	28.58	920.39
1996	5	0	0	194.12	724.59	32	67.31	1.72	104.92	770.58	6	313.96	0	0	735.54	43	93.90	1.28	100.65	760.34
1997						62	34.29	34.27	97.83	700.58	17	3.36	0	9.66	205.13	79	27.63	26.90	78.86	593.96
1998						28	115.80	5.38	73.08	763.14	10	91.83	3.37	12.72	428.54	38	109.49	4.85	57.20	675.09
Total	55	53.57	8.56	157.90	369.03	826	26.29	172.93	77.53	645.46	137	64.67	128.84	69.04	668.41	1018	32.93	158.12	80.73	633.61
Winter																				
1982						195	0.44	8.30	229.33	272.52						195	0.44	8.30	229.33	272.52
1986	79	9.22	361.10	2.78	390.24	354	6.81	1214.85	18.92	1434.28	18	5.45	28.38	221.74	313.73	451	7.18	1017.95	24.19	1206.68
1987	71	2.03	170.44	8.71	464.64	259	22.24	1117.39	1.55	1406.60						330	17.89	913.65	3.09	1203.94
1988	89	45.93	277.06	12.27	459.36	133	7.07	752.78	84.34	1062.12	8	12.54	101.54	146.28	300.10	230	22.30	546.05	58.61	802.37
1989	45	7.14	197.36	34.00	310.08	142	28.16	653.66	162.90	1019.13	3	0	1461.43	183.01	1644.44	190	22.74	558.34	132.69	861.07
1990	72	108.10	100.74	32.11	408.90	99	53.83	989.52	35.26	1486.58	5	0	36.35	446.67	517.90	176	74.50	598.85	45.66	1018.19
1991	41	33.52	19.20	4.43	179.91	102	44.45	664.56	4.29	936.41	1	34.14	538.66	125.46	853.53	144	41.27	479.94	5.17	720.44
1992	79	43.23	13.72	28.29	147.19	138	41.39	179.60	12.75	423.85	21	19.00	68.40	126.65	535.17	238	40.03	114.73	27.96	341.84
1993	80	44.45	15.94	17.70	305.01	90	14.68	1063.93	3.91	1397.89	28	7.23	826.27	152.35	1357.60	198	25.65	606.89	30.47	950.62
1994	96	22.88	36.26	42.68	434.53	90	26.83	698.80	4.15	986.92	26	1.28	149.98	66.14	607.32	212	21.91	331.47	29.20	690.23
1995	27	1.98	84.28	113.48	256.80	75	51.23	602.29	7.38	918.69	22	124.71	214.40	34.11	896.72	124	53.54	420.68	35.22	770.67
1996	69	0	76.51	142.72	499.54	189	13.64	721.67	19.47	1197.62	44	151.13	321.81	27.17	1084.42	302	30.56	516.01	48.75	1021.63
1997	48	0	313.61	71.04	516.90	116	46.13	211.08	0.82	655.44	28	86.66	420.65	95.03	1185.88	192	40.51	267.27	32.11	698.16
1998	31	18.69	171.48	299.65	520.56	125	493.62	108.47	14.89	1040.86	20	950.35	36.45	44.05	1627.67	176	461.87	111.38	68.36	1015.90
Total	827	29.31	140.23	47.54	381.58	2108	50.28	703.42	46.87	1057.11	224	141.49	295.91	99.12	958.33	3159	51.26	527.09	50.75	873.26

Table 9. Average weight (gm) of Atlantic cod, Arctic cod, and Capelin in samples (n) containing each prey species from nearshore areas of NAFO Divisions 2J3KL.

	2J			3K			3L			2J3KL		
	Atlantic Cod	Arctic Cod	Capelin	Atlantic Cod	Arctic Cod	Capelin	Atlantic Cod	Arctic Cod	Capelin	Atlantic Cod	Arctic Cod	Capelin
Summer												
1982		23.74 (2)		163.48 (2)	64.06 (17)	282.49 (48)				163.48 (2)	59.82 (19)	282.49 (48)
1986				152.13 (7)	662.91 (67)	299.07 (23)	151.19 (1)	22.90 (1)	125.66 (1)	152.01 (8)	653.50 (68)	291.84 (24)
1987				151.97 (6)	240.12 (19)	43.79 (4)			48.58 (1)	151.97 (6)	240.12 (19)	44.75 (5)
1988				54.94 (5)	136.07 (37)	442.58 (32)		23.41 (1)	1525.42 (1)	54.94 (5)	133.10 (38)	475.39 (33)
1989		18.67 (3)	283.09 (5)	34.83 (2)	31.66 (11)	128.94 (4)			481.55 (2)	34.83 (2)	28.88 (14)	263.12 (11)
1990				56.50 (10)	509.55 (27)	45.07 (21)		160.69 (2)	598.15 (7)	56.50 (10)	485.49 (29)	183.34 (28)
1991	208.08 (1)	12.78 (2)	243.62 (6)	76.37 (2)	666.46 (27)	78.60 (19)	47.04 (7)	1197.78 (11)	165.39 (10)	78.42 (7)	779.89 (40)	131.69 (35)
1992			546.59 (1)	109.37 (9)	328.10 (34)	236.62 (24)		356.30 (4)	34.65 (4)	109.37 (7)	331.07 (38)	219.45 (29)
1993	29.90 (4)	27.42 (3)	190.40 (7)	238.01 (9)	578.86 (39)	126.11 (23)	550.56 (3)	20.26 (1)	7.20 (1)	244.59 (16)	527.39 (40)	136.79 (31)
1994	327.35 (8)	259.61 (1)	211.23 (14)	335.96 (2)	407.47 (23)	217.59 (24)	916.03 (3)	164.82 (14)	5.77 (2)	464.53 (13)	314.18 (38)	204.77 (40)
1995				1812.60 (4)	463.95 (22)	86.49 (12)	315.53 (4)	80.28 (4)	126.39 (4)	1064.06 (8)	404.93 (26)	96.46 (16)
1996			194.12 (5)	430.77 (5)	55.04 (1)	279.80 (12)	1883.79 (1)			672.94 (6)	55.04 (1)	254.60 (17)
1997				354.38 (6)	84.99 (25)	151.64 (40)	28.58 (2)		82.14 (3)	272.93 (8)	84.99 (25)	148.33 (42)
1998				1621.26 (2)	21.54 (7)	146.15 (14)	229.57 (4)	33.66 (1)	31.80 (4)	693.46 (6)	23.05 (8)	120.74 (18)
Average	226.65 (13)	42.81 (11)	228.54 (38)	314.76 (71)	401.24 (356)	213.47 (300)	402.75 (25)	452.59 (39)	242.52 (40)	322.36 (104)	396.46 (406)	217.99 (377)
Winter												
1982				17.02 (5)	26.10 (62)	251.23(178)				17.02 (5)	26.10 (62)	251.23 (178)
1986	121.38 (6)	509.41 (56)	36.63 (6)	73.01 (33)	1424.03 (302)	93.02 (72)	49.02 (2)	39.30 (13)	285.10 (14)	78.92 (41)	1237.46 (371)	118.58 (92)
1987	48.09 9(3)	275.03 (44)	56.22 (11)	261.86 (22)	1425.63 (203)	25.07 (16)				236.21 (25)	1220.67 (247)	37.76 (27)
1988	1022.02 (4)	362.62 (68)	38.99 (28)	42.74 (22)	918.53 (109)	260.88 (43)	25.07 (4)	116.04 (7)	195.04 (6)	170.96 (30)	682.55 (184)	175.06 (77)
1989	24.72 (13)	227.72 (39)	109.29 (14)	137.88 (29)	807.13 (115)	312.59 (74)		1461.43 (3)	274.52 (2)	102.85 (42)	675.70 (157)	280.12 (90)
1990	1556.63 (5)	161.19 (45)	82.56 (28)	296.08 (18)	1379.75 (71)	166.24 (21)		90.88 (2)	446.67 (5)	570.11 (23)	893.20 (118)	148.82 (54)
1991	687.13 (2)	49.19 (16)	20.16 (9)	377.84 (12)	928.57 (73)	33.62 (13)	34.14 (1)	538.66 (1)	125.46 (1)	396.16 (15)	767.90 (90)	32.35 (23)
1992	487.91 (7)	40.13 (27)	171.92 (13)	336.02 (17)	516.34 (48)	195.53 (9)	79.81 (5)	95.75 (15)	204.59 (13)	328.51 (29)	303.38 (90)	190.13 (35)
1993	154.59 (23)	36.43 (35)	108.95 (13)	165.11 (8)	1679.89 (57)	87.90 (4)	101.22 (2)	1005.90 (23)	284.39 (15)	153.91 (33)	1044.91 (115)	188.55 (32)
1994	146.46 (15)	77.36 (45)	124.16 (33)	134.17 (18)	924.88 (68)	53.36 (7)	33.17 (1)	389.94 (10)	214.95 (8)	136.62 (34)	571.32 (123)	128.97 (48)
1995	10.71 (5)	133.86 (17)	218.86 (14)	256.14 (15)	903.43 (50)	46.10 (12)	548.72 (5)	362.84 (13)	75.03 (10)	265.57 (25)	652.05 (80)	121.32 (36)
1996		117.31 (45)	273.55 (36)	286.48 (9)	1251.33 (109)	184.03 (20)	738.83 (9)	643.62 (22)	239.05 (5)	512.66 (18)	885.42 (176)	241.37 (61)
1997		367.15 (41)	162.38 (21)	411.66 (13)	470.87 (52)	13.66 (7)	808.84 (3)	1070.73 (11)	241.91 (11)	486.13 (16)	493.43 (104)	158.11 (39)
1998	579.52 (1)	253.14 (21)	387.04 (24)	2804.68 (22)	347.67 (39)	84.58 (22)	2375.86 (8)	104.15 (7)	880.98 (1)	2622.24 (31)	292.60 (67)	255.98 (47)
Average	288.58 (84)	232.41 (499)	157.25 (250)	436.13 (243)	1091.91 (1358)	197.98 (499)	792.34 (40)	521.91(127)	243.98 (91)	441.18 (367)	839.25 (1984)	190.84 (840)

Table 10. Number of samples and prevalence (percent of samples) of Atlantic cod, in parentheses, by NAFO Unit Areas (south-north)

Year	334 (3Lq)	335 (3Lj)	336 (3Lf)	337 (3Lb)	338 (3La)	339 (3Ki)	340 (3Kh)	341 (3Kd)	342 (3Ka)	201 (2Jm)	208 (2Jd)	209 (2Ja)	Total
Summer													
1982						50 (2)	1 (0)	5 (0)	20 (5)	13 (0)			89 (2.3)
1986					1 (100)	61 (9.8)	3 (0)		35 (2.9)				100 (8)
1987	38 (2.6)	1 (0)			5 (0)	27 (0)	11 (45.5)	5 (20)	29 (0)				116 (6)
1988	17(5.9)				3 (0)	24 (16.7)	24 (4.2)		27 (0)				95 (6.3)
1989					2 (0)	3 (0)			47 (4.3)			5(0)	57 (3.5)
1990	19 (0)				7 (0)	13 (23.1)		6 (0)	25 (28)				70 (14.3)
1991			1 (0)		14 (28.6)	16 (6.3)	17 (0)	4 (0)	34 (2.9)		2 (0)	5 (20)	93 (7.5)
1992				4 (0)	8 (0)	15 (6.7)	13 (15.4)	3 (0)	25 (16)	2 (0)			70 (10)
1993					13 (23.1)	11 (0)	13 (38.5)	10 (30)	46 (2.2)	1 (100)		8 (37.5)	102 (15.7)
1994				2 (100)	20 (5)	11 (9.1)	10 (0)	14 (0)	15 (6.7)			14 (57.1)	86 (15.1)
1995				4 (0)	19 (21.1)	20 (15)	7 (14.3)		4 (0)				54 (14.8)
1996				6 (16.7)		11 (9.1)	4 (0)		17 (23.5)	5 (0)			43 (14)
1997	1 (0)			11 (0)	6 (33.3)	17 (17.6)	25 (8)		20 (5)				80 (10)
1998				5 (60)	5 (20)	9 (0)	6 (16.7)		13 (7.7)				38 (15.8)
Totals	75 (2.7)	1 (0)	1 (0)	32 (18.8)	103 (15.5)	288 (8.3)	134 (12.7)	47 (8.5)	357 (6.7)	21 (4.8)	2 (0)	32 (37.5)	1093 (8.2)
Winter													
1982						129 (1.6)	5 (0)	48 (6.3)	13 (0)				195 (2.6)
1986					18 (11.1)	89 (19.1)	76 (5.3)	79 (3.8)	110 (8.2)	67 (7.5)		12 (8.3)	451 (9.1)
1987						25 (8)	22 (50)	76 (5.3)	136 (3.7)	17 (11.8)	14 (0)	40 (2.5)	330 (7.6)
1988					8 (50)	13 (38.5)	55 (20)	35 (5.7)	30 (13.3)	35 (5.7)	6 (0)	48 (4.2)	230 (13)
1989					3 (0)	14 (42.9)	71 (25.4)	31 (6.4)	26 (11.5)	25 (16)	5 (20)	15 (53.3)	190 (22.1)
1990					5 (0)	16 (31.3)	14 (42.9)	35 (11.4)	34 (8.8)	25 (8)	16 (0)	31 (9.7)	176 (13.1)
1991					1 (100)	15 (26.7)	25 (16)	34 (8.8)	28 (3.8)	31 (3.2)		10 (10)	144 (10.4)
1992				4 (0)	17 (29.4)	14 (28.6)	12 (16.7)	10 (20)	102 (8.8)	35 (11.4)	37 (8.1)	7 (0)	238 (12.2)
1993				2 (0)	26 (7.7)	9 (22.2)	20 (20)	19 (5.3)	41 (2.4)	26 (26.9)	41 (34.1)	13 (15.4)	197 (16.8)
1994				15 (0)	11 (9.1)	19 (10.5)	24 (12.5)	5 (40)	42 (26.2)	39 (17.9)	31 (12.9)	26 (15.4)	212 (16)
1995	2 (0)				22 (22.7)	18 (11.1)	21 (19)		36 (25)		11 (9.1)	16 (25)	126 (19.8)
1996				10 (30)	34 (14.7)	73 (1.4)	29 (6.9)		87 (6.9)		28 (0)	41 (0)	302 (5.6)
1997				15 (20)	13 (0)	17 (11.8)	21 (23.8)		78 (7.7)		20 (0)	28 (0)	192 (8.3)
1998			1 (100)	8 (25)	11 (45.5)	24 (25)	27 (40.7)		74 (6.8)			31 (3.2)	176 (17.6)
Totals	2 (0)	0	1 (100)	54 (14.8)	169 (17.7)	475 (12.7)	422 (20.2)	372 (7)	838 (8.6)	300 (11.3)	209 (11)	318 (8.5)	3160 (11.6)

Table 9. Average weight (gm) of Atlantic cod, Arctic cod, and Capelin in samples (n) containing each prey species from nearshore areas of NAFO Divisions 2J3KL.

	2J			3K			3L			2J3KL		
	Atlantic Cod	Arctic Cod	Capelin	Atlantic Cod	Arctic Cod	Capelin	Atlantic Cod	Arctic Cod	Capelin	Atlantic Cod	Arctic Cod	Capelin
Summer												
1982		23.74 (2)		163.48 (2)	64.06 (17)	282.49 (48)				163.48 (2)	59.82 (19)	282.49 (48)
1986				152.13 (7)	662.91 (67)	299.07 (23)	151.19 (1)	22.90 (1)	125.66 (1)	152.01 (8)	653.50 (68)	291.84 (24)
1987				151.97 (6)	240.12 (19)	43.79 (4)			48.58 (1)	151.97 (6)	240.12 (19)	44.75 (5)
1988				54.94 (5)	136.07 (37)	442.58 (32)		23.41 (1)	1525.42 (1)	54.94 (5)	133.10 (38)	475.39 (33)
1989		18.67 (3)	283.09 (5)	34.83 (2)	31.66 (11)	128.94 (4)			481.55 (2)	34.83 (2)	28.88 (14)	263.12 (11)
1990				56.50 (10)	509.55 (27)	45.07 (21)		160.69 (2)	598.15 (7)	56.50 (10)	485.49 (29)	183.34 (28)
1991	208.08 (1)	12.78 (2)	243.62 (6)	76.37 (2)	666.46 (27)	78.60 (19)	47.04 (7)	1197.78 (11)	165.39 (10)	78.42 (7)	779.89 (40)	131.69 (35)
1992			546.59 (1)	109.37 (9)	328.10 (34)	236.62 (24)		356.30 (4)	34.65 (4)	109.37 (7)	331.07 (38)	219.45 (29)
1993	29.90 (4)	27.42 (3)	190.40 (7)	238.01 (9)	578.86 (39)	126.11 (23)	550.56 (3)	20.26 (1)	7.20 (1)	244.59 (16)	527.39 (40)	136.79 (31)
1994	327.35 (8)	259.61 (1)	211.23 (14)	335.96 (2)	407.47 (23)	217.59 (24)	916.03 (3)	164.82 (14)	5.77 (2)	464.53 (13)	314.18 (38)	204.77 (40)
1995				1812.60 (4)	463.95 (22)	86.49 (12)	315.53 (4)	80.28 (4)	126.39 (4)	1064.06 (8)	404.93 (26)	96.46 (16)
1996			194.12 (5)	430.77 (5)	55.04 (1)	279.80 (12)	1883.79 (1)			672.94 (6)	55.04 (1)	254.60 (17)
1997				354.38 (6)	84.99 (25)	151.64 (40)	28.58 (2)		82.14 (3)	272.93 (8)	84.99 (25)	148.33 (42)
1998				1621.26 (2)	21.54 (7)	146.15 (14)	229.57 (4)	33.66 (1)	31.80 (4)	693.46 (6)	23.05 (8)	120.74 (18)
Average	226.65 (13)	42.81 (11)	228.54 (38)	314.76 (71)	401.24 (356)	213.47 (300)	402.75 (25)	452.59 (39)	242.52 (40)	322.36 (104)	396.46 (406)	217.99 (377)
Winter												
1982				17.02 (5)	26.10 (62)	251.23(178)				17.02 (5)	26.10 (62)	251.23 (178)
1986	121.38 (6)	509.41 (56)	36.63 (6)	73.01 (33)	1424.03 (302)	93.02 (72)	49.02 (2)	39.30 (13)	285.10 (14)	78.92 (41)	1237.46 (371)	118.58 (92)
1987	48.09 9(3)	275.03 (44)	56.22 (11)	261.86 (22)	1425.63 (203)	25.07 (16)				236.21 (25)	1220.67 (247)	37.76 (27)
1988	1022.02 (4)	362.62 (68)	38.99 (28)	42.74 (22)	918.53 (109)	260.88 (43)	25.07 (4)	116.04 (7)	195.04 (6)	170.96 (30)	682.55 (184)	175.06 (77)
1989	24.72 (13)	227.72 (39)	109.29 (14)	137.88 (29)	807.13 (115)	312.59 (74)		1461.43 (3)	274.52 (2)	102.85 (42)	675.70 (157)	280.12 (90)
1990	1556.63 (5)	161.19 (45)	82.56 (28)	296.08 (18)	1379.75 (71)	166.24 (21)		90.88 (2)	446.67 (5)	570.11 (23)	893.20 (118)	148.82 (54)
1991	687.13 (2)	49.19 (16)	20.16 (9)	377.84 (12)	928.57 (73)	33.62 (13)	34.14 (1)	538.66 (1)	125.46 (1)	396.16 (15)	767.90 (90)	32.35 (23)
1992	487.91 (7)	40.13 (27)	171.92 (13)	336.02 (17)	516.34 (48)	195.53 (9)	79.81 (5)	95.75 (15)	204.59 (13)	328.51 (29)	303.38 (90)	190.13 (35)
1993	154.59 (23)	36.43 (35)	108.95 (13)	165.11 (8)	1679.89 (57)	87.90 (4)	101.22 (2)	1005.90 (23)	284.39 (15)	153.91 (33)	1044.91 (115)	188.55 (32)
1994	146.46 (15)	77.36 (45)	124.16 (33)	134.17 (18)	924.88 (68)	53.36 (7)	33.17 (1)	389.94 (10)	214.95 (8)	136.62 (34)	571.32 (123)	128.97 (48)
1995	10.71 (5)	133.86 (17)	218.86 (14)	256.14 (15)	903.43 (50)	46.10 (12)	548.72 (5)	362.84 (13)	75.03 (10)	265.57 (25)	652.05 (80)	121.32 (36)
1996		117.31 (45)	273.55 (36)	286.48 (9)	1251.33 (109)	184.03 (20)	738.83 (9)	643.62 (22)	239.05 (5)	512.66 (18)	885.42 (176)	241.37 (61)
1997		367.15 (41)	162.38 (21)	411.66 (13)	470.87 (52)	13.66 (7)	808.84 (3)	1070.73 (11)	241.91 (11)	486.13 (16)	493.43 (104)	158.11 (39)
1998	579.52 (1)	253.14 (21)	387.04 (24)	2804.68 (22)	347.67 (39)	84.58 (22)	2375.86 (8)	104.15 (7)	880.98 (1)	2622.24 (31)	292.60 (67)	255.98 (47)
Average	288.58 (84)	232.41 (499)	157.25 (250)	436.13 (243)	1091.91 (1358)	197.98 (499)	792.34 (40)	521.91(127)	243.98 (91)	441.18 (367)	839.25 (1984)	190.84 (840)

Table 10. Number of samples and prevalence (percent of samples) of Atlantic cod, in parentheses, by NAFO Unit Areas (south-north)

Year	334 (3Lq)	335 (3Lj)	336 (3Lf)	337 (3Lb)	338 (3La)	339 (3Ki)	340 (3Kh)	341 (3Kd)	342 (3Ka)	201 (2Jm)	208 (2Jd)	209 (2Ja)	Total
Summer													
1982						50 (2)	1 (0)	5 (0)	20 (5)	13 (0)			89 (2.3)
1986					1 (100)	61 (9.8)	3 (0)		35 (2.9)				100 (8)
1987	38 (2.6)	1 (0)			5 (0)	27 (0)	11 (45.5)	5 (20)	29 (0)				116 (6)
1988	17(5.9)				3 (0)	24 (16.7)	24 (4.2)		27 (0)				95 (6.3)
1989					2 (0)	3 (0)			47 (4.3)			5(0)	57 (3.5)
1990	19 (0)				7 (0)	13 (23.1)		6 (0)	25 (28)				70 (14.3)
1991			1 (0)		14 (28.6)	16 (6.3)	17 (0)	4 (0)	34 (2.9)		2 (0)	5 (20)	93 (7.5)
1992				4 (0)	8 (0)	15 (6.7)	13 (15.4)	3 (0)	25 (16)	2 (0)			70 (10)
1993					13 (23.1)	11 (0)	13 (38.5)	10 (30)	46 (2.2)	1 (100)		8 (37.5)	102 (15.7)
1994				2 (100)	20 (5)	11 (9.1)	10 (0)	14 (0)	15 (6.7)			14 (57.1)	86 (15.1)
1995				4 (0)	19 (21.1)	20 (15)	7 (14.3)		4 (0)				54 (14.8)
1996				6 (16.7)		11 (9.1)	4 (0)		17 (23.5)	5 (0)			43 (14)
1997	1 (0)			11 (0)	6 (33.3)	17 (17.6)	25 (8)		20 (5)				80 (10)
1998				5 (60)	5 (20)	9 (0)	6 (16.7)		13 (7.7)				38 (15.8)
Totals	75 (2.7)	1 (0)	1 (0)	32 (18.8)	103 (15.5)	288 (8.3)	134 (12.7)	47 (8.5)	357 (6.7)	21 (4.8)	2 (0)	32 (37.5)	1093 (8.2)
Winter													
1982						129 (1.6)	5 (0)	48 (6.3)	13 (0)				195 (2.6)
1986					18 (11.1)	89 (19.1)	76 (5.3)	79 (3.8)	110 (8.2)	67 (7.5)		12 (8.3)	451 (9.1)
1987						25 (8)	22 (50)	76 (5.3)	136 (3.7)	17 (11.8)	14 (0)	40 (2.5)	330 (7.6)
1988					8 (50)	13 (38.5)	55 (20)	35 (5.7)	30 (13.3)	35 (5.7)	6 (0)	48 (4.2)	230 (13)
1989					3 (0)	14 (42.9)	71 (25.4)	31 (6.4)	26 (11.5)	25 (16)	5 (20)	15 (53.3)	190 (22.1)
1990					5 (0)	16 (31.3)	14 (42.9)	35 (11.4)	34 (8.8)	25 (8)	16 (0)	31 (9.7)	176 (13.1)
1991					1 (100)	15 (26.7)	25 (16)	34 (8.8)	28 (3.8)	31 (3.2)		10 (10)	144 (10.4)
1992				4 (0)	17 (29.4)	14 (28.6)	12 (16.7)	10 (20)	102 (8.8)	35 (11.4)	37 (8.1)	7 (0)	238 (12.2)
1993				2 (0)	26 (7.7)	9 (22.2)	20 (20)	19 (5.3)	41 (2.4)	26 (26.9)	41 (34.1)	13 (15.4)	197 (16.8)
1994				15 (0)	11 (9.1)	19 (10.5)	24 (12.5)	5 (40)	42 (26.2)	39 (17.9)	31 (12.9)	26 (15.4)	212 (16)
1995	2 (0)				22 (22.7)	18 (11.1)	21 (19)		36 (25)		11 (9.1)	16 (25)	126 (19.8)
1996				10 (30)	34 (14.7)	73 (1.4)	29 (6.9)		87 (6.9)		28 (0)	41 (0)	302 (5.6)
1997				15 (20)	13 (0)	17 (11.8)	21 (23.8)		78 (7.7)		20 (0)	28 (0)	192 (8.3)
1998			1 (100)	8 (25)	11 (45.5)	24 (25)	27 (40.7)		74 (6.8)			31 (3.2)	176 (17.6)
Totals	2 (0)	0	1 (100)	54 (14.8)	169 (17.7)	475 (12.7)	422 (20.2)	372 (7)	838 (8.6)	300 (11.3)	209 (11)	318 (8.5)	3160 (11.6)

Table 11. Number of measurable Atlantic cod and average estimated lengths (cm) by NAFO Unit areas (south-north).

	336 (3Lj)		337 (3Lb)		338 (3La)		339 (3Ki)		340 (3Kh)		341 (3Kd)		342 (3Ka)		201 (2Jm)		208 (2Jd)		209 (2Ja)		Total	Overall
	N	Length	N	Length	N	Length	N	Length	N	Length	N	Length	N	Length	N	Length	N	Length	N	Length	N	Average
Summer																						
1982							2	9.109					1	4.499							3	7.57
1986					8	12.5	9	22.6					3	11.8							20	16.94
1987									29	13.69	1	10.34									30	13.58
1988							21	9.643	3	11.17											24	9.83
1989													2	16.22							2	16.22
1990							3	10.8					12	13.31							15	12.81
1991					4	16.36	1	23.26					1						1	9.387	7	14.01
1992							4	16.27	5	18.67			14	8.41							23	12.01
1993					13	20.42			8	25.65	3	22.67	1	24.36	1	11.28			3	15.29	29	21.39
1994			1	33.51	1	30.01	1	42.38					1	13.79					8	10.28	12	16.83
1995					11	19.63	26	27.6	1	29.65											38	25.35
1996			11	20.96			1	18.8					34	12.48							46	14.65
1997					2	13.2	4	20.64	3	29.01			1	7.224							10	20.32
1998			9	14.74	1	26.15			3	41.88			2	14.43							15	20.89
Totals			21		40		72		52		4		72		1				12		274	
Winter																						
1982							3	12.29			6	7.549									9	9.13
1986					6	11.43	48	13.29	7	18.32	3	11.37	9	13.28	11	14.35			1	13.04	85	13.64
1987							2	10.58	85	13.11	29	8.792	8	17.79	2	8.334			17	8.993	143	11.90
1988					8	11.08	12	11.17	27	10.19	12	7.558	4	17.39	6	22.42			6	29.78	75	12.95
1989							22	16.17	78	13.94	7	10.16	5	32.72	6	13.58	1	19.86	33	7.018	152	13.23
1990							8	20.21	20	17.46	4	15.6	7	18.39	7	24.08			14	35.17	60	22.72
1991					3	11.03	7	20.98	9	28.02	15	13.96	2	25.61	5	24.25			5	18	46	19.65
1992					15	13.88	9	22.09	14	13.9	2	20.01	14	19.28	5	22.72	5	34.09			64	18.68
1993					4	17.93	3	17.48	18	17.84	1	21.67	1	13.87	15	9.287	86	8.849	2	38.54	130	11.22
1994					1	16.16	2	25.26	4	25.52	13	8.92	42	8.547	41	8.415	35	7.996	15	16.8	153	9.94
1995					17	20.92	2	28.22	7	33.14			12	11.47			4	7.936	14	7.024	56	16.28
1996			2	23.11	10	36.9	1	37.23	5	18.54			20	13.28							38	21.34
1997			4	38.69			5	24.2	7	33.75			6	15.81							22	27.59
1998	1	17.9	2	39.8	17	40.58	18	41.5	30	33.77			8	14.77					1	40.8	77	35.15
Totals	1		8		81		142		311		92		138		98		131		108		1110	

Table 12. Estimated consumption (tonnes) of Capelin, Arctic cod and Atlantic cod in 2J3KL 1965-2000. Variance incorporates uncertainty in population size, diet, residency time in 2J3KL and proportion of the population in nearshore (<25km) areas.

	Capelin			Arctic Cod			Atlantic Cod		
Year	-5% Perc	Mean	+95% Perc	-5% Perc	Mean	+95% Perc	-5% Perc	Mean	+95% Perc
1965	246,957	322,732	394,597	21,330	67,138	162,061	5,304	13,275	22,244
1966	251,119	327,918	400,579	21,406	68,227	165,295	5,332	13,489	23,033
1967	242,758	320,654	394,048	20,979	66,675	162,511	5,235	13,190	22,451
1968	235,806	310,705	380,585	20,295	64,655	157,966	5,105	12,781	21,696
1969	241,297	318,508	389,006	20,843	66,281	162,283	5,223	13,107	22,280
1970	236,878	312,068	379,786	20,202	64,931	157,636	5,069	12,839	21,544
1971	236,251	309,310	377,809	20,449	64,317	156,929	5,079	12,721	21,736
1972	236,902	311,336	382,909	20,459	64,792	157,258	5,173	12,807	21,870
1973	249,039	328,878	402,757	21,620	68,434	166,181	5,322	13,534	22,868
1974	263,343	347,273	423,897	22,604	72,269	175,365	5,625	14,289	24,032
1975	277,688	363,811	444,604	23,872	75,693	183,745	5,971	14,963	25,421
1976	287,591	376,128	458,922	24,565	78,319	189,913	6,123	15,479	26,191
1977	296,651	388,009	473,643	25,519	80,745	195,668	6,407	15,968	26,932
1978	309,266	402,818	490,435	26,189	83,832	204,438	6,600	16,573	28,148
1979	318,418	417,806	509,176	27,230	86,916	211,830	6,826	17,192	29,357
1980	332,315	435,453	533,210	28,455	90,619	219,448	7,098	17,912	30,420
1981	346,010	452,992	554,932	29,766	94,278	230,674	7,380	18,638	31,565
1982	354,183	464,446	568,346	30,253	96,635	236,190	7,521	19,111	32,555
1983	365,843	479,229	585,157	31,073	99,716	240,257	7,832	19,720	33,289
1984	388,257	510,553	623,812	33,300	106,231	257,690	8,294	21,003	35,523
1985	413,196	545,826	670,193	35,731	113,655	272,726	8,896	22,463	37,946
1986	445,724	584,022	715,486	38,361	121,537	293,270	9,603	24,030	40,982
1987	467,879	617,649	755,528	40,471	128,495	312,873	10,123	25,408	42,684
1988	488,531	641,734	787,092	42,066	133,518	321,913	10,507	26,392	45,038
1989	500,912	659,601	807,314	43,284	137,191	338,359	10,691	27,137	46,570
1990	520,843	685,971	838,896	45,246	142,811	349,298	11,256	28,224	48,065
1991	546,291	716,685	877,178	47,115	149,057	367,405	11,675	29,489	49,734
1992	567,808	750,840	915,321	49,379	156,305	377,124	12,174	30,887	52,129
1993	595,478	783,251	957,397	51,109	162,978	400,169	12,749	32,230	55,416
1994	620,128	821,232	1,004,858	53,924	170,980	415,144	13,411	33,787	57,462
1995	645,448	850,284	1,036,817	56,288	177,244	428,201	14,030	35,035	59,076
1996	673,016	883,955	1,084,192	57,861	183,878	446,701	14,469	36,368	61,509
1997	677,793	885,223	1,077,853	57,304	184,512	446,890	14,454	36,423	61,536
1998	681,228	888,690	1,092,781	58,230	185,106	459,448	14,718	36,547	61,473
1999	683,847	888,776	1,089,607	57,548	185,090	464,771	14,215	36,585	61,691
2000	682,184	893,281	1,100,558	58,282	185,959	457,367	14,413	36,725	62,438

Table 11. Number of measurable Atlantic cod and average estimated lengths (cm) by NAFO Unit areas (south-north).

	336 (3Lj)		337 (3Lb)		338 (3La)		339 (3Ki)		340 (3Kh)		341 (3Kd)		342 (3Ka)		201 (2Jm)		208 (2Jd)		209 (2Ja)		Total	Overall
	N	Length	N	Length	N	Length	N	Length	N	Length	N	Length	N	Length	N	Length	N	Length	N	Length	N	Average
Summer																						
1982							2	9.109					1	4.499							3	7.57
1986					8	12.5	9	22.6					3	11.8							20	16.94
1987									29	13.69	1	10.34									30	13.58
1988							21	9.643	3	11.17											24	9.83
1989													2	16.22							2	16.22
1990							3	10.8					12	13.31							15	12.81
1991					4	16.36	1	23.26					1						1	9.387	7	14.01
1992							4	16.27	5	18.67			14	8.41							23	12.01
1993					13	20.42			8	25.65	3	22.67	1	24.36	1	11.28			3	15.29	29	21.39
1994			1	33.51	1	30.01	1	42.38					1	13.79					8	10.28	12	16.83
1995					11	19.63	26	27.6	1	29.65											38	25.35
1996			11	20.96			1	18.8					34	12.48							46	14.65
1997					2	13.2	4	20.64	3	29.01			1	7.224							10	20.32
1998			9	14.74	1	26.15			3	41.88			2	14.43							15	20.89
Totals			21		40		72		52		4		72		1				12		274	
Winter																						
1982							3	12.29			6	7.549									9	9.13
1986					6	11.43	48	13.29	7	18.32	3	11.37	9	13.28	11	14.35			1	13.04	85	13.64
1987							2	10.58	85	13.11	29	8.792	8	17.79	2	8.334			17	8.993	143	11.90
1988					8	11.08	12	11.17	27	10.19	12	7.558	4	17.39	6	22.42			6	29.78	75	12.95
1989							22	16.17	78	13.94	7	10.16	5	32.72	6	13.58	1	19.86	33	7.018	152	13.23
1990							8	20.21	20	17.46	4	15.6	7	18.39	7	24.08			14	35.17	60	22.72
1991					3	11.03	7	20.98	9	28.02	15	13.96	2	25.61	5	24.25			5	18	46	19.65
1992					15	13.88	9	22.09	14	13.9	2	20.01	14	19.28	5	22.72	5	34.09			64	18.68
1993					4	17.93	3	17.48	18	17.84	1	21.67	1	13.87	15	9.287	86	8.849	2	38.54	130	11.22
1994					1	16.16	2	25.26	4	25.52	13	8.92	42	8.547	41	8.415	35	7.996	15	16.8	153	9.94
1995					17	20.92	2	28.22	7	33.14			12	11.47			4	7.936	14	7.024	56	16.28
1996			2	23.11	10	36.9	1	37.23	5	18.54			20	13.28							38	21.34
1997			4	38.69			5	24.2	7	33.75			6	15.81							22	27.59
1998	1	17.9	2	39.8	17	40.58	18	41.5	30	33.77			8	14.77					1	40.8	77	35.15
Totals	1		8		81		142		311		92		138		98		131		108		1110	

Table 12. Estimated consumption (tonnes) of Capelin, Arctic cod and Atlantic cod in 2J3KL 1965-2000. Variance incorporates uncertainty in population size, diet, residency time in 2J3KL and proportion of the population in nearshore (<25km) areas.

	Capelin			Arctic Cod			Atlantic Cod		
Year	-5% Perc	Mean	+95% Perc	-5% Perc	Mean	+95% Perc	-5% Perc	Mean	+95% Perc
1965	246,957	322,732	394,597	21,330	67,138	162,061	5,304	13,275	22,244
1966	251,119	327,918	400,579	21,406	68,227	165,295	5,332	13,489	23,033
1967	242,758	320,654	394,048	20,979	66,675	162,511	5,235	13,190	22,451
1968	235,806	310,705	380,585	20,295	64,655	157,966	5,105	12,781	21,696
1969	241,297	318,508	389,006	20,843	66,281	162,283	5,223	13,107	22,280
1970	236,878	312,068	379,786	20,202	64,931	157,636	5,069	12,839	21,544
1971	236,251	309,310	377,809	20,449	64,317	156,929	5,079	12,721	21,736
1972	236,902	311,336	382,909	20,459	64,792	157,258	5,173	12,807	21,870
1973	249,039	328,878	402,757	21,620	68,434	166,181	5,322	13,534	22,868
1974	263,343	347,273	423,897	22,604	72,269	175,365	5,625	14,289	24,032
1975	277,688	363,811	444,604	23,872	75,693	185,745	5,971	14,963	25,421
1976	287,591	376,128	458,922	24,565	78,319	189,913	6,123	15,479	26,191
1977	296,651	388,009	473,643	25,519	80,745	195,668	6,407	15,968	26,932
1978	309,266	402,818	490,435	26,189	83,832	204,438	6,600	16,573	28,148
1979	318,418	417,806	509,176	27,230	86,916	211,830	6,826	17,192	29,357
1980	332,315	435,453	533,210	28,455	90,619	219,448	7,098	17,912	30,420
1981	346,010	452,992	554,932	29,766	94,278	230,674	7,380	18,638	31,565
1982	354,183	464,446	568,346	30,253	96,635	236,190	7,521	19,111	32,555
1983	365,843	479,229	585,157	31,073	99,716	240,257	7,832	19,720	33,289
1984	388,257	510,553	623,812	33,300	106,231	257,690	8,294	21,003	35,523
1985	413,196	545,826	670,193	35,731	113,655	272,726	8,896	22,463	37,946
1986	445,724	584,022	715,486	38,361	121,537	293,270	9,603	24,030	40,982
1987	467,879	617,649	755,528	40,471	128,495	312,873	10,123	25,408	42,684
1988	488,531	641,734	787,092	42,066	133,518	321,913	10,507	26,392	45,038
1989	500,912	659,601	807,314	43,284	137,191	338,359	10,691	27,137	46,570
1990	520,843	685,971	838,896	45,246	142,811	349,298	11,256	28,224	48,065
1991	546,291	716,685	877,178	47,115	149,057	367,405	11,675	29,489	49,734
1992	567,808	750,840	915,321	49,379	156,305	377,124	12,174	30,887	52,129
1993	595,478	783,251	957,397	51,109	162,978	400,169	12,749	32,230	55,416
1994	620,128	821,232	1,004,858	53,924	170,980	415,144	13,411	33,787	57,462
1995	645,448	850,284	1,036,817	56,288	177,244	428,201	14,030	35,035	59,076
1996	673,016	883,955	1,084,192	57,861	183,878	446,701	14,469	36,368	61,509
1997	677,793	885,223	1,077,853	57,304	184,512	446,890	14,454	36,423	61,536
1998	681,228	888,690	1,092,781	58,230	185,106	459,448	14,718	36,547	61,473
1999	683,847	888,776	1,089,607	57,548	185,090	464,771	14,215	36,585	61,691
2000	682,184	893,281	1,100,558	58,282	185,959	457,367	14,413	36,725	62,438

Figure 1. North Atlantic Fisheries Organization (NAFO) Scientific and Statistical Divisions and Subdivisions.

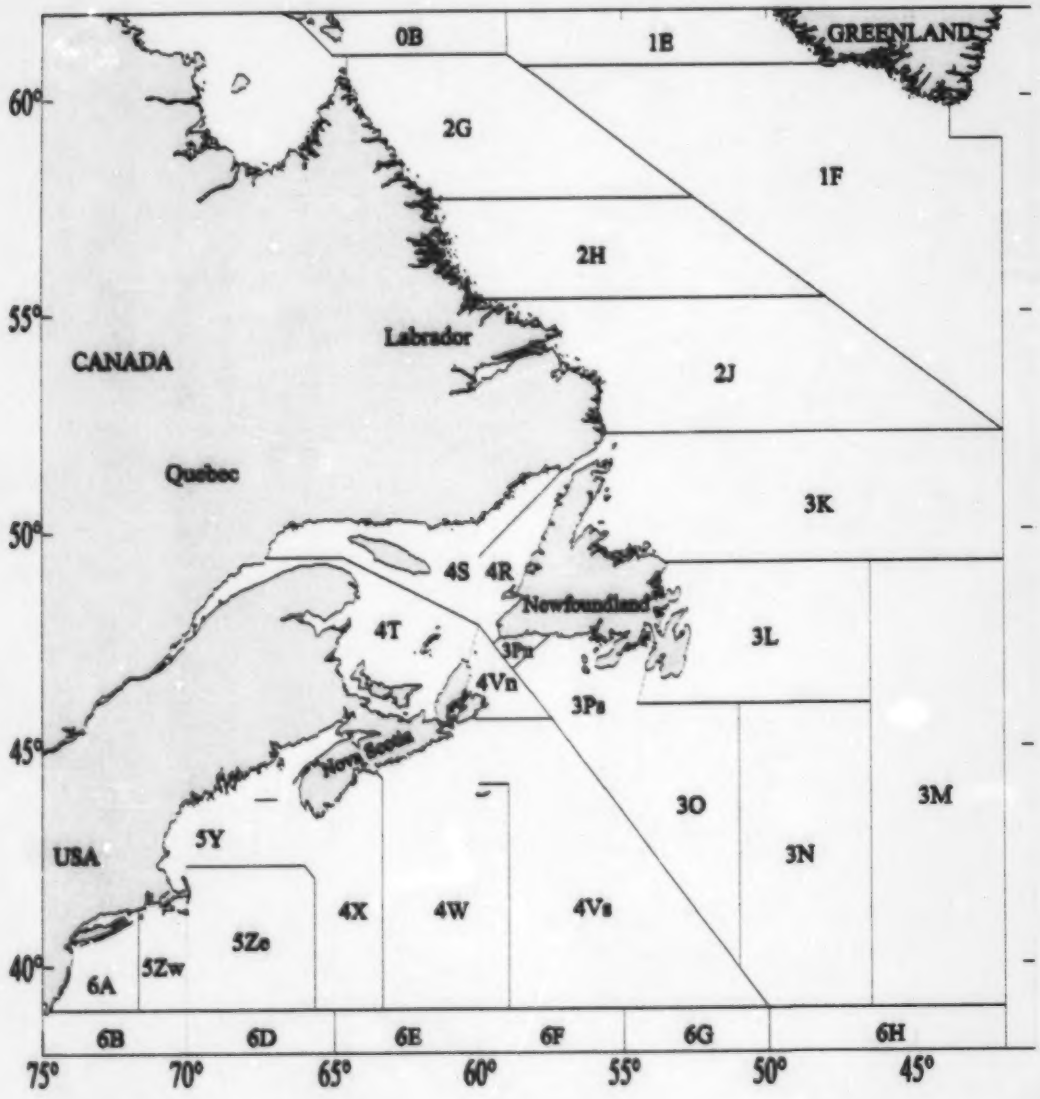

Figure 2. Locations of harp seals determined by satellite telemetry (1993-1997) used to determine residency time in 2J3KL and proportion of population in nearshore and offshore areas.

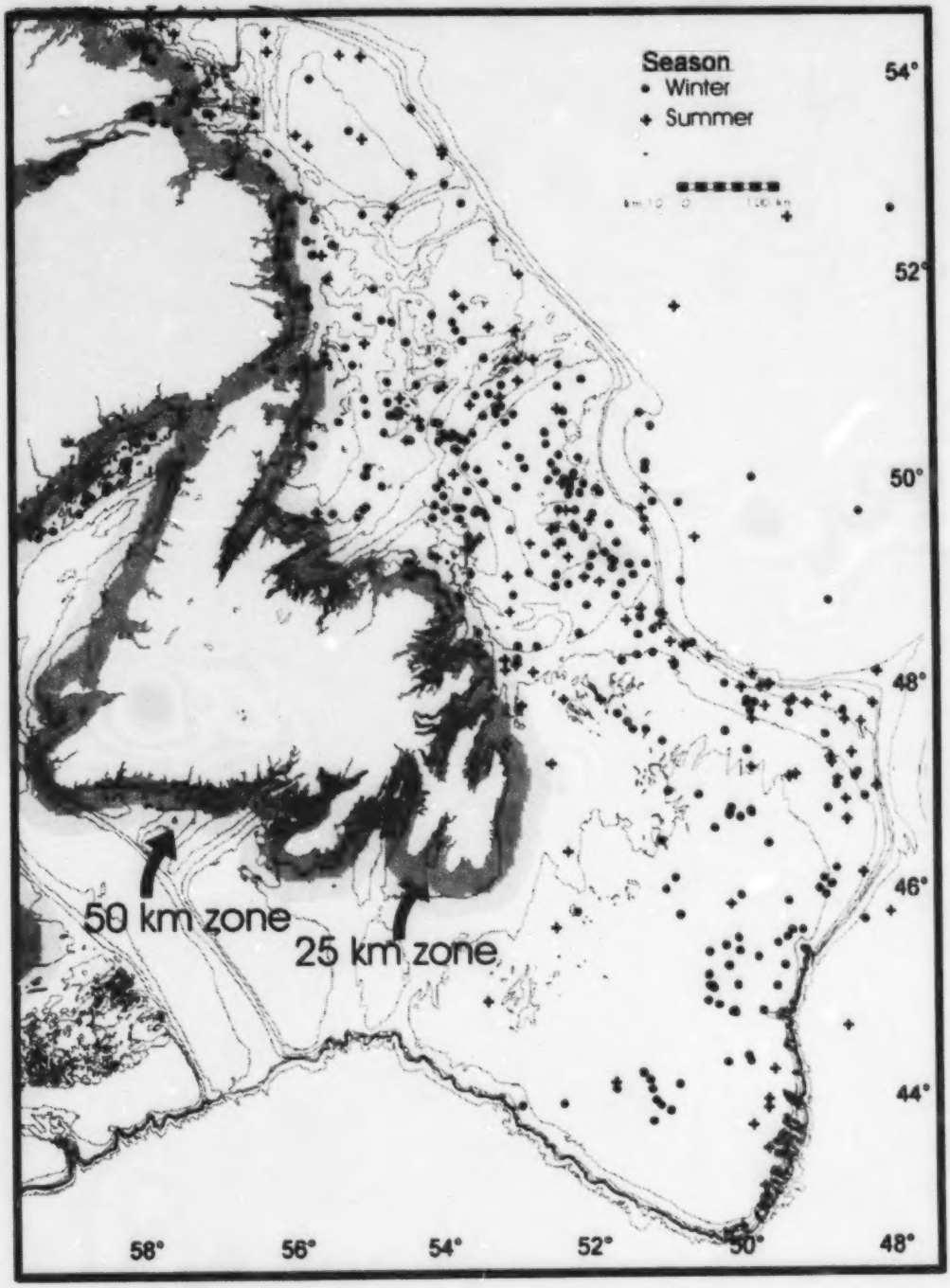

Figure 3. Estimated consumption (and 95% C.I.) of Capelin in 2J3KL by harp seals, 1965-2000, based on average diets. 95% C.I. based upon uncertainty in abundance, diet, residency in 2J3KL and the proportion of seals in nearshore areas.

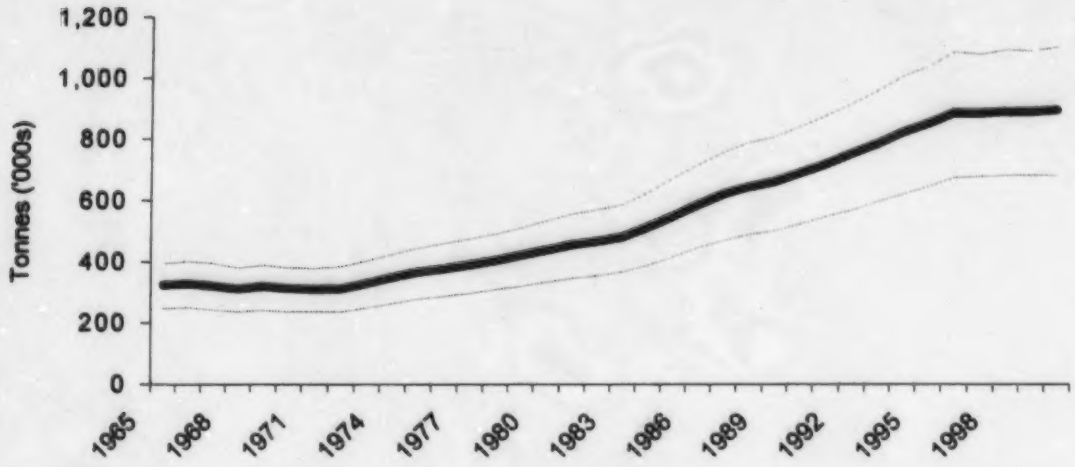

Figure 4. Estimated consumption (and 95% C.I.) of Arctic cod in 2J3KL by harp seals, 1965-2000, based on average diets. 95% C.I. based upon uncertainty in abundance, diet, residency in 2J3KL and the proportion of seals in nearshore areas.

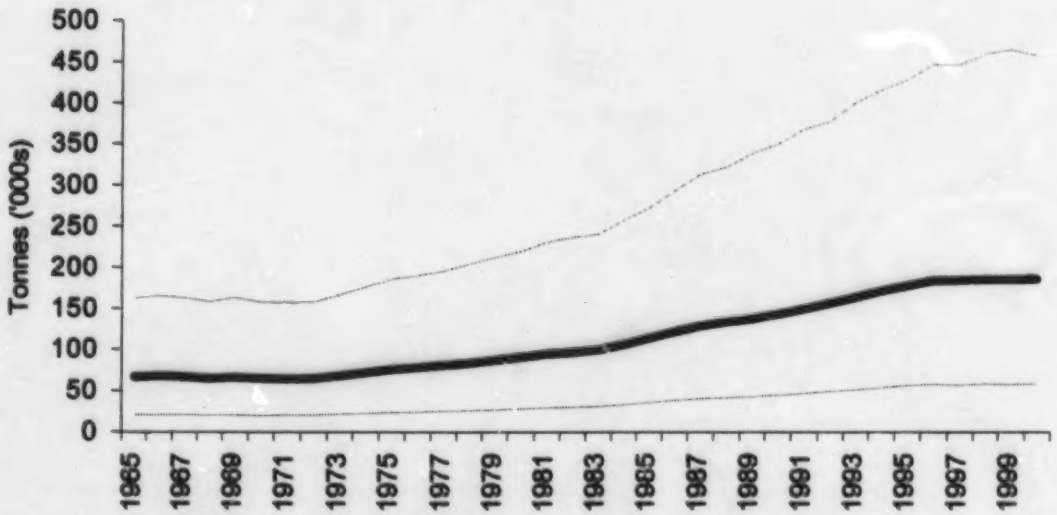

Figure 5. Estimated consumption (and 95% C.I.) of Atlantic cod in 2J3KL by harp seals, 1965-2000, based on average diets. 95% C.I. based upon uncertainty in abundance, diet, residency in 2J3KL and the proportion of seals in nearshore areas.